AUGUST, 1960
Vol. 14, No. 8

FT food technology

THE JOURNAL OF THE INSTITUTE OF FOOD TECHNOLOGISTS

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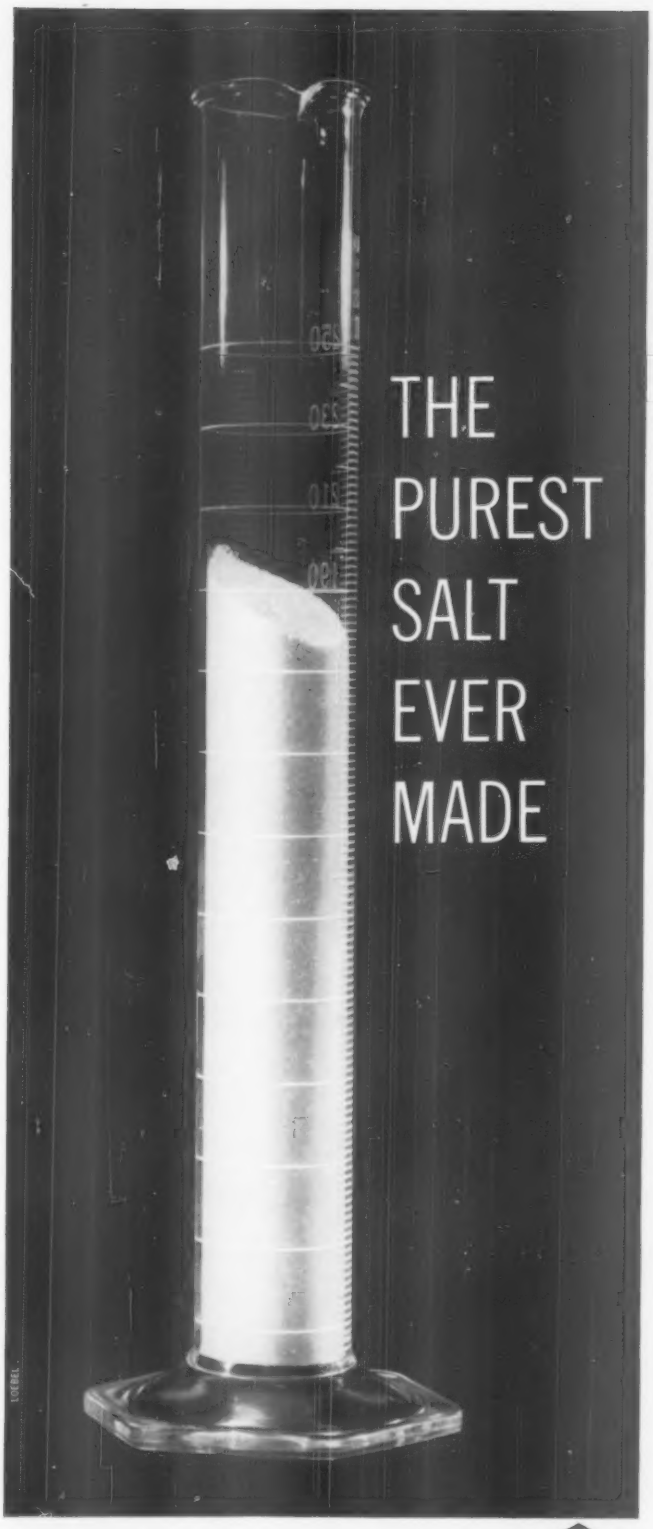

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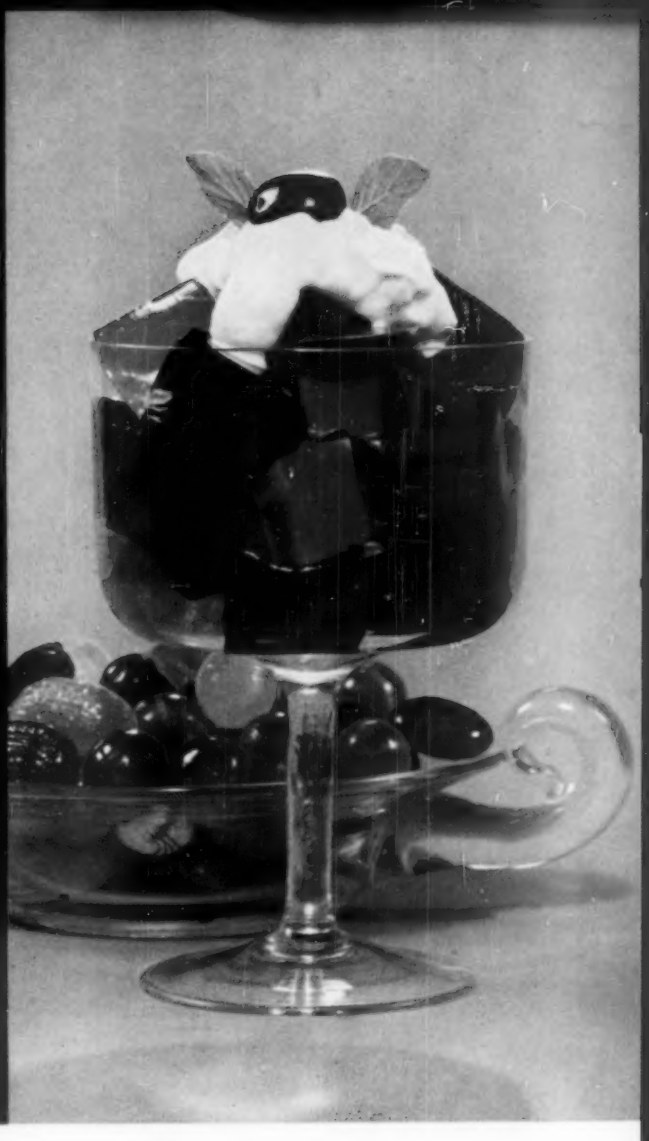

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The Years Past and the Years Ahead

The Presidential Address, 1960

Ray B. Wakefield
President, Institute of Food Technologists, 1959-60

FROM FLORIDA to British Columbia, from Boston to Los Angeles, and from Mexico City to Minneapolis, your President, during the past two years, has traveled to visit with our Regional Sections (28 in all). My visit to the Hawaiian Section later in the month will complete a tour to all the Regional Sections except the ones in Australia and Japan.

Ray B. Wakefield, Past President of IFT, 1959-1960

This has indeed been a tiring and time-consuming job, but I met so many old friends and made so many new ones, that this alone made it worthwhile. In addition there is no better way of getting right next to the problems of our Institute and learning how our individual members feel about them.

We are growing up. Indeed, I have repeatedly run into signs of the growing pains. Now, this can be either good or bad. Let's take a look to see where we stand, where we have come from, and where we are going.

HOW FAR HAVE WE COME?

Please travel back with me to the early 1940's. What do you find?

A small group of dedicated people stimulated by the founder of the group (Dean Prescott) started to develop a professional organization in the area of Food Technology.

Remember those early days when every detail was settled by the Council, and they stayed in session most of the night to get the job done?

Remember that we had only a part-time Secretary and Editor?

Remember how we were trying to start a Journal and find the money to keep it going?

There was no income from advertising, exhibits, etc. Yes, it was indeed a dedicated group. Their earnestness and pioneering spirit attracted other serious scientists and technologists—and IFT kept growing.

What kind of people were these? First of all, they represented a cross section of technical people interested in all aspects of foods. IFT in those years, as it does today, consisted of professors teaching some phase of food science and technology; people performing research in the universities, government laboratories and industrial organizations; the technical people from those industries supplying basic materials to the food processing industries; men concerned with the procurement of raw materials; men handling the processing and production of foods; and those involved in the technical aspects of selling food products.

IFT was "professional people" devoted to furthering the science and technology of foods, not people from one specialized part of the giant food industry, but people from all parts: canning, freezing, dehydrating, dairy manufacturing, brewing, milling, breakfast cereals, candy and confectionery, and many other specialized fields of food manufacture. And there were people at work in university laboratories from New England to California, from Florida to the State of Washington and in government laboratories from Beltsville to Pasadena.

It was indeed a polyglot group of people. But they got together and pooled their varied interests and acting informally as a group nurtured the Society through its early days.

WHERE DO WE STAND TODAY?

Let's take a look at us today.

We now have a full time Executive Secretary, an Assistant Executive Secretary, an Advertising Manager, and two assistants in our Chicago office.

We have an editor and his capable wife who spend many hours on our two Journals.

We sell approximately $100,000 of advertising and derive about $15,000 from the exhibits each year.

We have an annual budget of approximately $200,000 and have been able to set up a reserve fund well in excess of $100,000.

We now have approximately 6,000 members to whom we are obligated to supply services.

We are no longer a struggling society, we are growing up. From hundreds we have grown to thousands. Now what does this mean? Primarily, it means that we are no longer able to do things on exactly the same old informal basis of years ago.

August Cover. Seventy-nine IFT'ers and their families preparing to embark on a flight to the Pacific Rim Food Conference, Honolulu, Hawaii, May 19–29. In addition to numerous field trips and attendant sunburns, most of the technical sessions proved to be of interest to those in attendance. Efficiency marked the Conference, which left little time for anything but working, eating, and sleeping. All returned safely, although there is some speculation as to the connection between the gathering of Food Technologists and the incidence of tidal waves.

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1. We need and have an Executive Committee to act for the Council.
2. We must, of necessity, and do, give a greater range of responsibility to the various standing committees.
3. We find it necessary, because of size, to place greater responsibility in the Central Office for the handling of the Annual Meeting.
4. Details, which in the past were done informally by volunteer leadership, must now be handled by the Executive Office.

Communications are becoming more difficult and will continue to be so more and more as we grow larger. I have no figures to show the number of letters, long distance phone calls, and telegrams required to communicate IFT business in 1950 as against the volume required in 1960, but I know one thing, the increase would be amazing. Our continuous growth will require us to make more use of the Executive Office, but we must never cease to strive to maintain that old informal relationship among our members.

Now why is this necessary?

Because for one important reason, that of the ever-increasing diversification of interests and activities of our membership.

The old, informal spirit of IFT certainly played a part, a vital part, in getting people of diverse interests together and to develop mutual respect for each other. We have learned about each other's problems—at our meetings, regional and national and in the halls and corridors at a meeting such as this. This is one of our strengths. We must never lose the personal touch. The opportunities for those of widely varied interests to interchange experiences, "person to person" are all too few, so let it be the personal obligation of each and every member of IFT to preserve the fine group spirit that was born when IFT was born.

To appreciate each other, we must recognize the basic requirements of each group:

1. The academic man, the basic research worker, the government research man is primarily interested in the scientific aspects of our Institute. And well he should be, because he wants:
   a. High quality journals with top notch, fresh, scientific material.
   b. A high calibre, effectively organized, scientific program at the Annual Meeting.
   c. Scholarships, research grants to encourage more students to enroll in Food Technology, etc. with the industry and the Institute solidly behind this effort.

A few of our members would like this to be a purely scientific society consisting of men like themselves. They would prefer no exhibits at our Annual Meetings, no advertising and no non-technical material in the Journals, etc. One has to respect such high ideals, but most scientific people recognize that it is important to achieve balance and to have in our Society technically minded, commercial people who are concerned with the procurement, processing and sell-

ing of foods. Mainly through contacts afforded by the Institute, our highly trained scientists have come to know these commercial people and to appreciate their contributions. Neither science nor industry can afford to be islands unto themselves. They are both a part of the mainland of human life.

2. The outlook of these commercial people, as could be expected, is different. They want:

a. More practical technical material, the so-called non-technical part of the Food Technology Journal.

b. They have, in general, no objections to advertising and can recognize that from a business standpoint, it helps underwrite the expensive tables and charts used in the Journals and keeps the cost of dues down.

c. They not only want exhibits at the Annual Meeting, but many of our members come to the meeting for the sole purpose of talking to the suppliers and learning what is new in machinery, products, etc.

d. They, as a rule, are not interested in reading Food Research. But they want it to be a prestige journal, a "long hair journal," if you wish, and would be very disturbed if they learned that it didn't carry this top level prestige.

e. Most of them want IFT to be a professional society but not solely a scientific one.

f. Also, most of them respect and appreciate the contributions of our scientific members. They want them as active members and want to be able to have the opportunity of meeting with them.

Of these groups we have brought together, each is getting something different out of the Society, but invariably getting something worthwhile from each other. We must provide that which interests all of our groups. We must understand the demands of each and we must continue to encourage the exchange between them as we have during the years. And I say again, let us keep the informal spirit of professional fellowship alive in IFT.

What have your officers been doing this year to take care of our growing Institute?

1. First, your president and president-elect, Dr. Hutchings have been visiting the Regional Sections to maintain an active communication with the regional groups and keep them informed of the activity taking place in this Society across our country and in foreign lands.

2. Next, we have tried to appoint committees to cover all areas of importance and staff them with capable people and encourage them to carry on active work; we believe we have been successful in this endeavor.

3. In keeping with our growing size, we have now set up our major operating committees so that provision is made for rotation of members. As a result, we are always in a position of having experienced members on these committees. The committees now in this category are the Executive Committee, Constitution and By-Laws, Finance, Publications and Qualifications. The Awards Committee and the Award Juries are also set up on a formal basis with the membership requirements outlined in the Rules and Regulations.

4. Members concerned with scientific matters, are, of course, interested in the activities of the Awards, Education and Publications Committees. In addition to our Annual Meeting Program Committee, we have this year a Program Advisory Committee to study our overall program policy. We have appointed several ad hoc committees to handle special problems. These include: Career Day activities, International Congress, Study of the IFT Journals, and Ways and Means of Advancing the Science of Food Technology. The technical committees on Citrus, Food Additives and Taste Testing are of interest to many of our group and they are doing fine work.

5. The committees on Civil Defense, History and Regional Boundaries continue to do good work in their specific areas. The committees on Nominations, Resolutions and Membership are necessary to keep the affairs of the Institute moving along.

6. Our representatives to the Agricultural Research Council, The Association for the Advancement of Science, the Food and Nutrition Board and the International Institute of Refrigeration are all performing an important service.

7. The committee on Public Relations has been active this year and its work is of considerable im-

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portance to the Institute. We must develop a sound program of disseminating information on the importance of Food Technology.

You should know about a newly appointed technical committee on "Quality Control in Food Products." This should be of interest to many of our members in the Institute and it is my feeling that if it becomes really active, it will bring new members into the fold.

These committees provide the backbone of the Institute and as we grow become more and more important.

I should like to report on some events in which you might be interested that took place this past year.

1. In September I presented the charter to the Rocky Mountain Section at Denver, a fine group that will contribute to the work and prestige of the IFT. The group in and around Louisville is in the process of organizing our 33rd Section to be called the "Blue Grass" Section. They, also, will be a welcome addition to our Society.

2. Dr. Mrak has been very active on the international aspects of Food Technology. Your council has approved our collaboration with the Society of Chemical Industry to hold the first International Food Congress in London in 1962.

3. We have had several meetings with Mr. George Larrick of the Food and Drug Administration to see whether there are any acceptable ways that the IFT can be of assistance to the F. D. A.

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4. Time marches on and all people reach the age of retirement. Several years ago your officers saw this coming and appointed a small committee to begin working on the matter of the orderly replacement of our Editor and Executive Secretary when the time arrived for their retirement.

This time has now arrived and the transition will take place sometime during 1961.

Because of the work of this committee, we are not now faced with an emergency and should be able to make the transition in an orderly fashion. Your Executive Committee and Council has given this considerable thought and consideration. I should like to point out the years of devoted, inspired service that both Colonel Lawrence and Dr. Martin Peterson have performed for our Institute. They have both given of themselves way beyond the call of duty because of their interest in seeing us grow and prosper. Each and everyone of us owes them a debt of gratitude. Devotion such as they have shown can never be repaid.

Yes, we have grown but I think we still maintain the atmosphere of an informal group.

1. We are financially strong.
2. We have two active and growing Journals.
3. We have been able to provide programs that have attracted all segments of our membership with their varied interests.
4. We have strength in actively working committees covering all phases of the Institute activities.
5. We have strength in our dedicated people in the Executive and Editorial Offices.
6. We have attained strength by the welding together of the many diverse segments of technical people from all avenues of this great food field. This could well be our greatest strength since it gives us the kind of "Cross Fertilization" of ideas that inspires progress in science and technology.

WHERE ARE WE GOING?

Now, what do I see for the future?

1. We must continue to evaluate and improve our Journals. We must make sure that they meet the requirements of all segments of our membership.

2. We must work out the best way to communicate with our membership and keep them informed of happenings in the Institute and in doing this we must determine whether our publication, FOOD TECHNOLOGY, is the proper medium to accomplish this objective.

3. We must be certain that the Executive Office does a good job of running the Annual Meetings but at all times keep in mind that we wish to retain the informal atmosphere that has always prevailed at these meetings.

4. We must continue with strong committees and must give them even more responsibilities and the authority that goes along with responsibility. Some of these committees can contribute substantially to food industry progress. They deserve our full interest and support.

5. We must continue to broaden our scope and make ourselves a truly international organization.

6. We must continue to serve our members in the best possible way and always keep our minds open for new and acceptable ways of serving the membership. For example, we have certain groups who feel we should become more active in the area of providing an employment service. We should carefully consider this from all angles.

7. We must encourage more students to enroll in Food Science and Technology and also encourage our universities to continually provide the best possible curriculum for training these young people.

Yes, we indeed will have things to keep us busy for many years to come.

Let us continue to keep all the communication channels open to enjoy all these benefits and continue to grow and prosper as a professional society representing the breadth, and reflecting the spectrum, of all the sciences and technologies dealing with foods. It is truly a great opportunity and a great challenge which faces us. I am certain that each and everyone of us will willingly accept this challenge, and within the framework of good fellowship, professional responsibility, and "realistic" idealism, help IFT continue its impressive growth.

In closing, may I, as I reach the last days of my term of office as your President, again express my appreciation for the honor you have accorded me. I sincerely hope that in some small measure I have fulfilled the trust you placed in me. The Institute of Food Technologists has had a great past and can look forward to a great future. I am proud to have served the membership over the past year in the office of President, and I can assure you that my interest in, and my enthusiasm for IFT will not cease when my term of office ends.

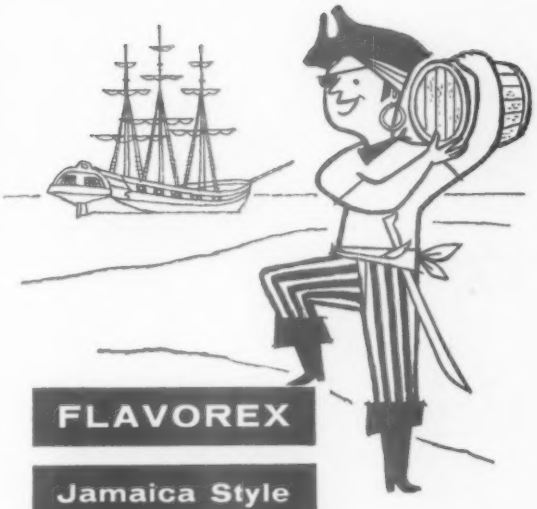
Synopsis of the Proceedings of the Annual Meeting of the IFT Council

San Francisco, May 15, 1960

A brief synopsis of the Annual Meeting of the Council on May 15, 1960, is herewith placed on record.

New Editor. Effective January 1, 1961, Editor-in-Chief of FOOD TECHNOLOGY and FOOD RESEARCH will be Dr. George F. Stewart, Head, Department of Food Science and Technology, University of California, Davis. Dr. Martin S. Peterson will continue in his present capacity until that time, and upon retirement, will be presented with a Resolution of Appreciation for his services.

New Section. Upon proper application, a "Bluegrass Section" of the Institute has been approved,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which will consist of the state of Kentucky less two counties immediately opposite Cincinnati, Ohio, plus three counties in Indiana immediately adjacent Louisville. Section officers are: Chairman, Dr. William J. Shannon; Secretary, Joe C. James; Councilor, Hamilton W. Putnam.

F. D. A. Liaison. The principle of representatives of the Institute discussing with the Food and Drug Administration ways and means of extending the professional resources of the Institute at the request of the FDA is approved, within the general area outlined by Ray Wakefield, viz., that the President of the Institute and a small committee approach the FDA and outline the purposes of the IFT and qualifications of the Membership. Should the FDA so desire, we shall make available to them a committee to work as a scientific advisory group; however it is pointed out that while maintaining a high level professional and scientific approach, the IFT must steer clear of anything concerned with political activity, lobbying, establishment of standards, etc.

New Executive Secretary. The Ad Hoc Committee on Administrative Policy, now under chairmanship of Ray Wakefield, has been granted authority to select and hire an Executive Secretary as successor to Colonel Lawrence—this action in view of the contemplated retirement of Colonel C. S. Lawrence.

REPORTS

Treasurer's Report. Assets as of April 30, 1959 were $215,608.10 *versus* $276,565.28 on March 31, 1960. Sources of income which yielded over $10,000 each last year include: dues, FOOD TECHNOLOGY and FOOD RESEARCH subscriptions, advertising (over $100,000), and the Annual Meeting. Expenses for the past fiscal year which amounted to over $10,000 each include: printing and mailing of FOOD TECHNOLOGY and FOOD RESEARCH, advertising sales expense, and salaries (including editor's office). Institute operations yielded $20,149.54, and FOOD TECHNOLOGY ended last year in the black to the extent of $25,693.76. FOOD RESEARCH went into the red in the amount of $1,418.28. A 1960–61 budget has been approved, with $222,550.00 in receipts anticipated and $222,190.00 in expenditures anticipated, for a net gain of $360.00.

Executive Secretary's Report. It is noted that total membership in the Institute is now 5,714—an increase of 63 for the fiscal year, 35 of whom are foreign members.

A recommendation proposing geographical rotation of Annual Meetings is accepted, and four areas will receive a proportionate share of Meetings based upon IFT population. Allocations for the first 12 years beginning with 1960 are as follows: eastern—5; southern—1; western—2; midwest and central—4. Specifically, Kansas City has been chosen for 1965, and Los Angeles for 1966.

Also accepted is a proposal that Emeritus Memberships be granted to members who are retired from active professional life and who have: 1) been a member of the Institute at least twenty (20) years, or 2) joined the Institute prior to 1940. These members will be required to pay a $5.00 subscription fee if they desire to receive FOOD TECHNOLOGY, otherwise they shall be exempt from dues, and retain all rights and privileges held prior to retirement.

International Congress of Food Technology. London, 1962, is the planned site and date for an International Congress of Food Technology. There is no anticipated call upon the Institute to lend financial support to this undertaking.

Civil Defense. A bulletin entitled "Civil Defense in the Food Industry" has been completed by Dr. Robert Baldwin of the committee, and a method of publishing and distributing it will be further investigated. The bulletin is organized as a handbook for use by Food Technologists in the event of a chemical, biological, or radiological attack on the United States.

Public Relations. A committee will investigate possible costs involved in establishing a sound public relations program for the Institute through use of a public relations firm.

Advancing the Science of Food Technology. Ten $300.00 scholarships will be made available this year to certain educational institutions qualifying, as determined by the Executive and Education Committees. Awardees, from freshman through senior years in college, will be selected by the Head of Department, with a maximum of four such awards to be given to any one school.

Publications. Sixteen hundred pages are scheduled for FOOD TECHNOLOGY during the fiscal year, of which 55% will be technical editorial matter. Advertising will occupy 34%, and non-technical editorial matter the remaining 11%. During the last 11-month fiscal year, 1394 pages were used.

Qualifications for Membership. Because of growth in activity of the Institute in Japan, a Foreign Aide will be selected who will submit all applications for memberships from that country.

OTHER HIGHLIGHTS

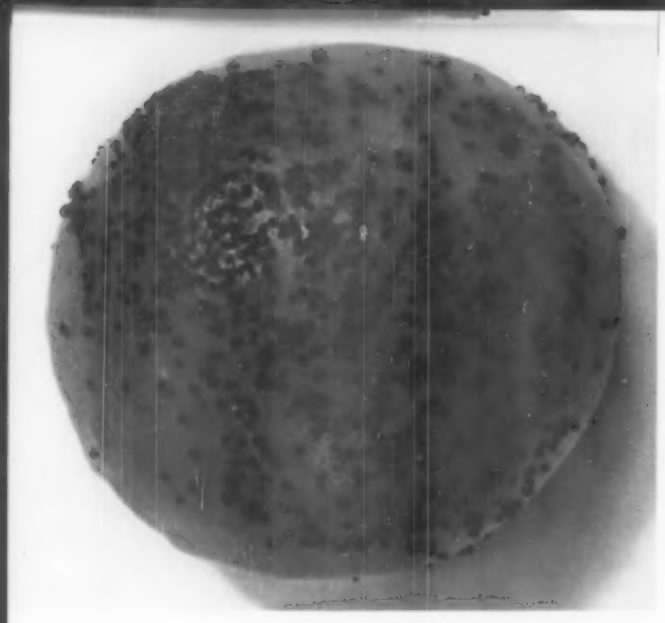
Officers Reappointed. Arthur N. Prater and W. Ray Junk will retain the posts of Treasurer and Assistant Treasurer, respectively, and Colonel Lawrence and Marian Gilchrist will again be Executive Secretary and Assistant Executive Secretary.

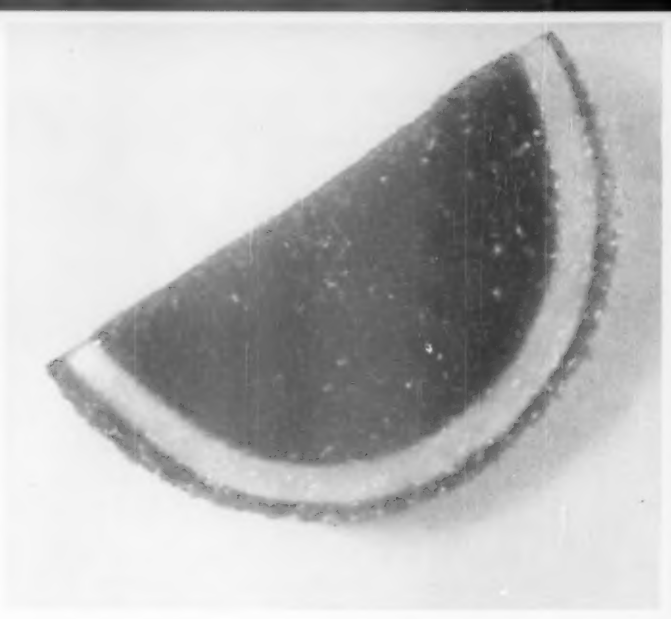
Retirement Provision. In view of the anticipated retirement of Colonel Lawrence, Executive Secretary of the Institute, a sum of $10,000 has been appropriated to provide a retirement income for him.

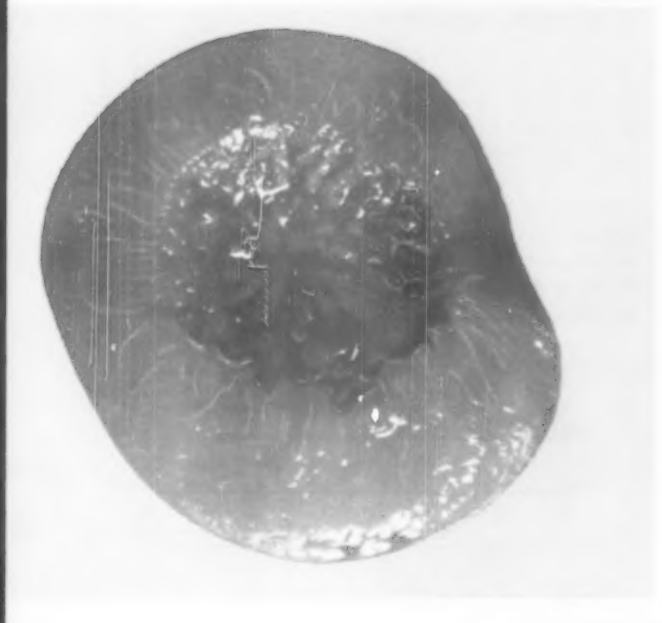
Employment Assistance Policy. The Northern California Section proposed a centralized employment service by the Institute; however, due to pitfalls including the loss of tax-exempt status possibly involved, an Ad Hoc Committee will study and recommend action along these lines.

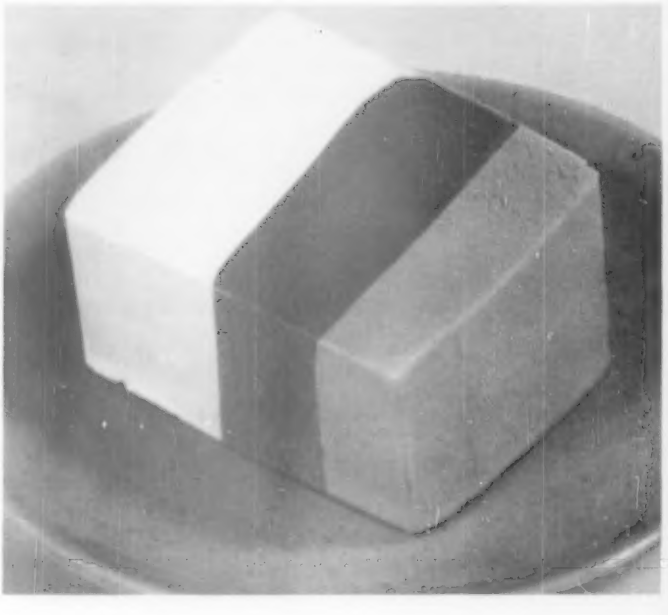
Invested Reserve Income. These funds will be made available for the purpose of furthering the constitutional objectives of the Institute upon authorization of the Executive Committee.

Post Convention Meetings. The proposal of Marcial Ibarra of the Mexico Section to hold a Latin American Food Conference on Food Technology under the joint sponsorship of the Mexico Section and the Institute is endorsed in principle.









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Are Your Earnings Comparable to that of Other Food Technologists?

Robert C. Slunder
Institute of Food Technologists, Chicago

UNDERPAID? An affirmative answer is probably given by ninety-nine out of a hundred people. What can be done by an individual to improve his income (specifically a food technologist)? A good question, difficult to answer, with a few thoughts presented here which may offer some clues.

Many of your fellow food technologists feel they are underpaid, while others apparently seem to think they are overpaid—at least they are asking for less than present earnings. Individuals employed in our profession vary markedly with regard to salaries. These variations occur within at least four categories: 1) education, 2) length of employment, 3) geographical location of employment, 4) organization by whom employed.

Here are the facts concerning the first two categories. Table 1 is a tabulation of resumes submitted by IFT members presumably available for employment. These resumes are those that have passed through the office of the Executive Secretary, IFT, in recent months. Of the 171 resumes, 87 are from individuals with a B.A. or B.S. degree, 42 have M.S. degrees, and 42 hold a Ph.D. Figures shown in Table 1 are based on the following percentages of information filled in:

Actual salary		Asking salary	
Degree	% filled in	Degree	% filled in
B.A./B.S.	65.5	B.A./B.S.	88.5
M.S.	45.2	M.S.	83.3
Ph.D.	47.6	Ph.D.	69.0

In other words, 52.8% of all individuals concerned listed their present salary, and 80.3% listed their salary requirements.

Table 2, an arithmetical derivation of Table 1, shows differences between actual salary and asking salary for the lowest and highest paid food technologists, as well as average figures. Figure 1 depicts the route of actual and asking salaries as experience is gained.

Since you now realize that each additional degree earned netted an individual in our group $100 a month more for the first three years of employment, perhaps you are checking through your old college catalog. But what set of circumstances influences

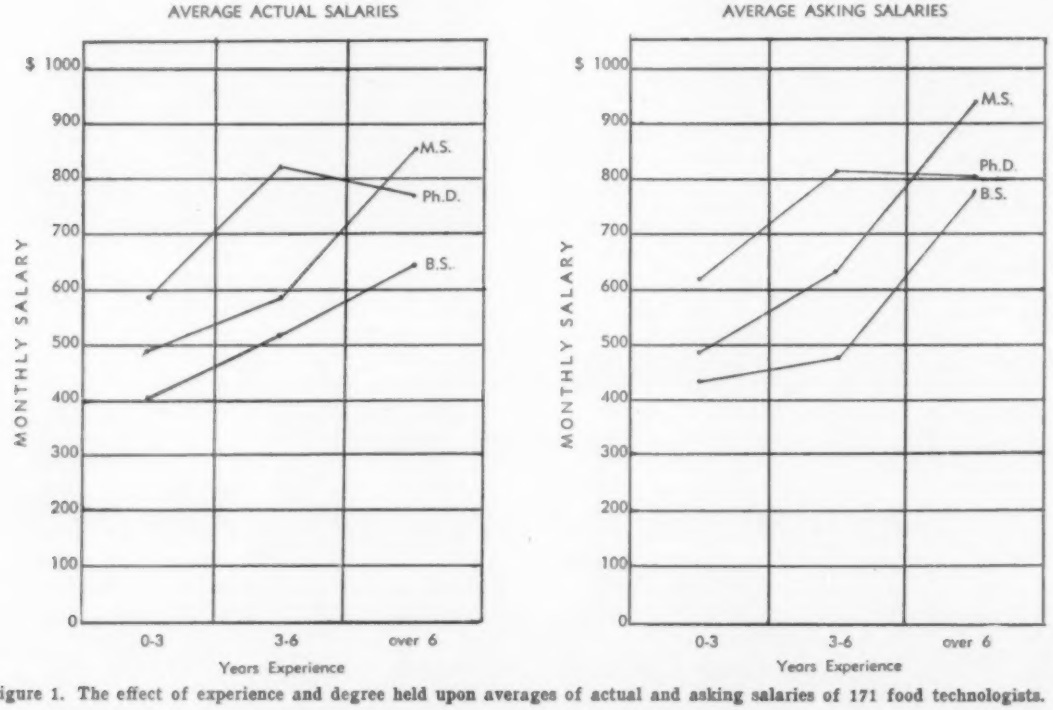

Figure 1. The effect of experience and degree held upon averages of actual and asking salaries of 171 food technologists.

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TABLE 1

Actual and asking salaries of 171 college graduate food technologists

Degree	Status	Actual salary a month Years experience 0–3	3–6	Over 6	Asking salary a month Years experience 0–3	3–6	Over 6
B.A. B.S.*	Low	$346	$ 412	$ 400	$339	$ 417	$ 500
	High	550	666	1666	583	750	2083
	Average	410	516	658	438	485	780
	Median	400	525	658	438	485	780
M.S.	Low	495	524	566	350	458	608
	High	495	626	1310	583	892	1500
	Average	495	592	863	488	629	939
	Median	495	600	833	500	583	934
Ph.D.	Low	500	666	633	458	608	625
	High	733	1166	1000	917	1000	1000
	Average	593	830	781	620	812	803
	Median	584	744	779	583	842	833

* Includes two individuals with no college degree.

Ph.D.'s with six or more years experience to be satisfied with present or decreasing earnings?

While resumes submitted to the Executive Secretary's office probably do not represent a true picture of all food technologists, they are typical of a certain group. This group feels a certain dissatisfaction with their present positions, and health, attitude of superiors, marital reasons, monetary reasons, or curiosity may be the motivations for "looking around."

TABLE 2

Difference between actual and asking salary of 171 food technologists

Degree	Status	Years experience 0–3	3–6	Over 6
B.A. B.S.	Low	$(−) 7	$ 5	$ 100
	High	33	84	417
	Average	28	(−) 31	122
M.S.	Low	(−)145	(−) 66	42
	High	88	166	190
	Average	(−) 13	37	76
Ph.D.	Low	(−) 42	(−) 56	(−) 8
	High	174	(−)166	0
	Average	27	(−) 18	22

A minus (−) indicates that actual earnings are higher than asking salary.

One may be static or dynamic in his attitude toward earning ability and potential. While it is not recommended to change positions often, very few men in any profession remain employed by one organization from the time they leave college until retiring. Since this is true, perhaps it would be well to learn and then study your attributes and shortcomings. Much more important is taking action to improve yourself—eliminate shortcomings, better your personality and attitude toward others, develop experience and proficiency in your special field, expose yourself to opportunities available by developing wider acquaintanceship with colleagues in other firms. A good way to accomplish the latter is to attend IFT Section meetings.

Two facets which affect variation in salary for food technologists, education and length of employment, have been compared among IFT members in the United States who are "looking around." In most cases, a B.S. or M.S. degree holder will earn and ask for consistently higher salaries as experience increases. This is true for Ph.D.'s until six years of experience is gained, after which salary requirements seem to decline. Another facet, organization by whom employed, will be discussed in a forthcoming issue of FOOD TECHNOLOGY.

An individual who considers himself "underpaid" might begin a program to eliminate his shortcomings, improve himself personally and technically, and become acquainted with colleagues through attendance at IFT Section meetings. Employers won't necessarily swamp you with offers, but you can toot your own horn in subtle ways by adapting the above suggestions to your situation.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1960

August 29-September 9	Second International Course on Lyophilization, Lyon, France
September 1-7	Fifth International Congress on Nutrition, Washington, D. C.
September 11-16	American Chemical Society's 138th national meeting, New York, New York
September 20-21	Military-Industry Conference on Freeze-Drying and other Dehydration Methods of Food Preservation, Sponsored by Research and Development Associates, Stock Yard Inn, Chicago, Illinois. (For information write Col. R. A. Isker, U.S.A. ret'd, Research and Development Associates, 1819 W. Pershing Road, Chicago, Ill.)
September 20-23	Pure Food Centenary, Royal Institution of Great Britain, London, England
October 4-7	Tenth Annual Instrument Symposium and Research Equipment Exhibit, National Institutes of Health, Bethesda, Maryland
October 12-14	The Seventh National Symposium of the American Vacuum Society, Cleveland-Sheraton Hotel, Cleveland, Ohio
November 12-19	Fifth Pan American Congress of Pharmacy and Biochemistry, Santiago, Chile. (For information address Senor José Pérez Molina, Secretary, Box 6084, Santiago, Chile).

1961	
May 7-11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 10-14	**Twenty-second Annual Meeting of the Institute of Food Technologists, Fontainebleau Hotel, Eden Roc Hotel, Miami Beach, Florida**
1963	
May 19-23	**Twenty-third Annual Meeting of the Institute of Food Technologists, Pantlind Hotel, Civic Auditorium, Grand Rapids, Michigan**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

*Among the North American Indians, lean meat, dried and pounded fine, packed in sacks of hide.

*PEMMICAN KEPT FOR MONTHS IN THE SUN But Tasted Like Baked Leather

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IN THIS ISSUE—

TECHNICAL ARTICLES IN BRIEF

Preference *Levels of sugar, canned corn*

The effect of added levels of sugar on consumer acceptance of whole kernel corn. K. G. Weckel, Bruce Strong, G. F. Garnatz, and Margaret Lyle.

Within the range 3.0% to 8.7% sugar in the brine (equivalent to 40–120 lb/150 gal) added to canned whole kernel corn in 5 levels, there was a definite significant consumer preference for the highest levels. Because the data are self limiting, acceptance of still higher levels of added sugar was not determined. It appears, however that maximum levels of acceptability of sweetness were approximately outlined and determined. These levels of preference of sweetness are on the average greater than those presently used in commercial canning of whole kernel corn. There does not appear to be any consistent effect of age or sex on preference of level of sweetness of the canned corn. Use of increased levels of added sugar in the canned corn results in an increase in soluble and total solids of the corn, but is without effect on alcohol insoluble solids as measured for grading purposes. Use of increased levels of sugar in the canned corn is without significant effect on the steam table tolerance of the corn. (See page 369).

Acid composition *McIntosh, Red Delicious, and Golden Delicious apples*

Organic acids in the apple as related to variety and source. A. L. Kenworthy and Norman Harris.

Three apple varieties, McIntosh, Red Delicious, and Golden Delicious, were studied in regard to organic acid composition. Two lots of Golden Delicious were used—one from Michigan and one from Washington. The McIntosh, Red Delicious and Golden Delicious samples were from the same orchard in Michigan. The four lots of apples were compared as to pressure test, soluble solids, per cent dry weight, rate of CO_2 evolution and the per cent of juice. Marked differences in these factors were found and may reflect genetic, or environmental factors which in turn would influence the acid composition. Total acidity was highest for the Michigan Golden Delicious and lowest for the Washington Golden Delicious. (See page 372).

Tenderization phenomena *Chicken breast muscle*

Changes in protein extractability during post-rigor tenderization of chicken breast muscle. B. Weinberg and Dyson Rose.

Pectoralis major muscles of young chickens were extracted with phosphate-potassium chloride buffer, pH 7.5, ionic concentration 0.55, and the extracts fractionated by dilution to lower ionic concentrations. The amount of nitrogen extracted increased when carcasses were held for 24 hours at 4° C. This increase was entirely accounted for by an increase in the "actomyosin" fraction. Since less free "myosin" was present in post-rigor than in pre-rigor extracts, despite an increase in total "myosin" plus "actomyosin", it is suggested that more actin was extracted from post-rigor meat and that this actin combined with "myosin" in the extract. More "myosin" or "actomyosin" was also extracted post-rigor. It is suggested that tenderization is not merely random autolysis but results from a specific cleavage of an actin association responsible for the maintenance of the muscle matrix. (See page 376).

Radiation preservation *Effect of packaging on shelf life of irradiated fish*

Irradiation preservation of Pacific Northwest fish: precooked fish sticks. David T. Miyauchi.

The effect of packaging on the shelf life of precooked breaded fish sticks irradiated at various doses up to 2 megarads and stored at two temperatures—room temperature and 35° F—was studied. For room temperature storage hermetically sealed cans were used. Mylar-polyethylene pouches were used for the 35° F storage. Results show the limitations of low level irradiation. (See page 379).

Taste perception *Sodium benzoate*

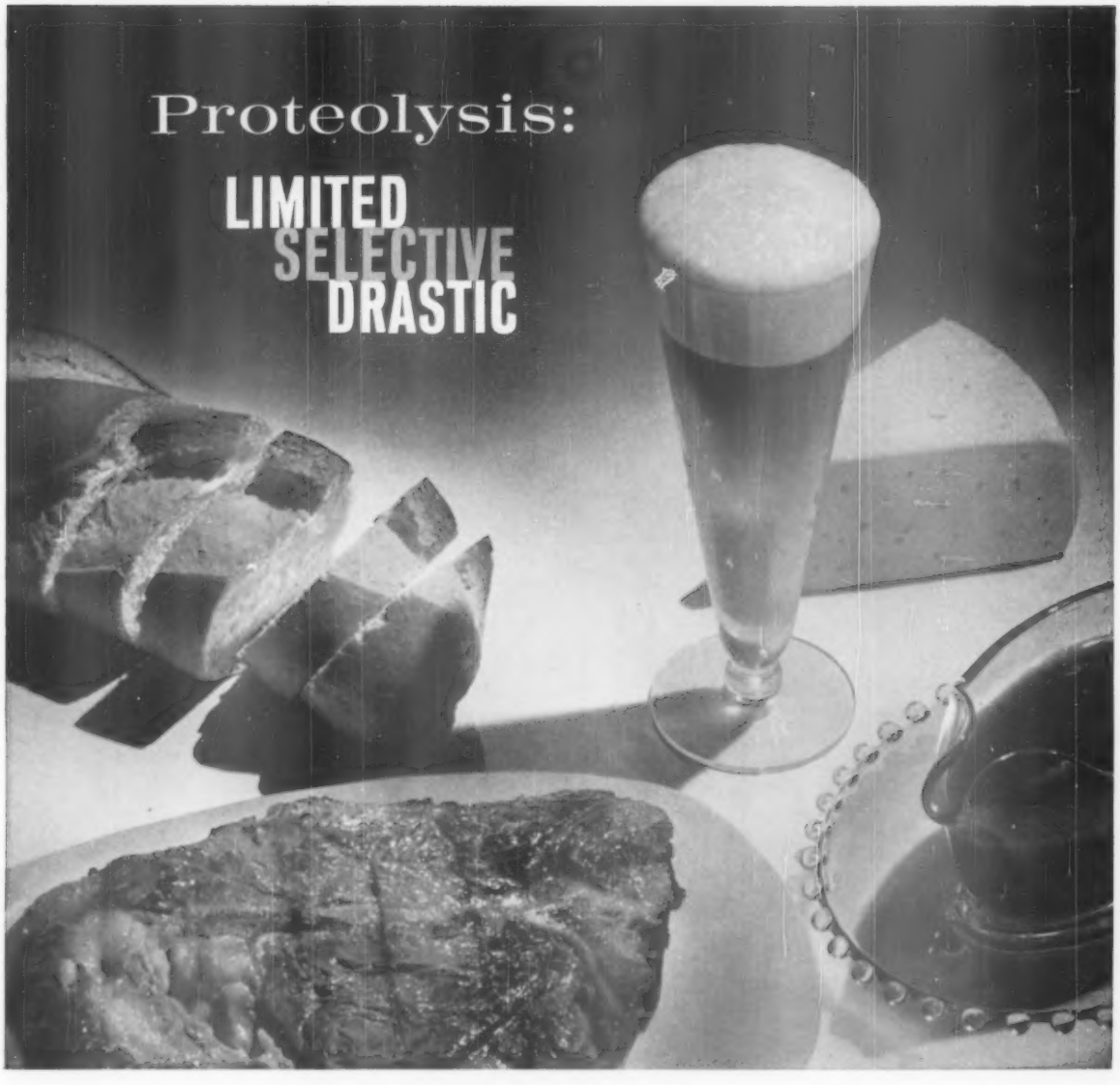
The variable taste perception of sodium benzoate. David Peryam.

The qualitative responses to sodium benzoate (sour, salt, sweet, bitter) vary among individuals but the data derived from this study do not indicate that the responses could be used to classify test populations, as has been maintained. Basic physiological differences among people may partially explain the differences in perception but it is likely that differences among people in learning, verbal habits, and the language used to describe their taste experiences are also involved. (See page 383).

Dehydration *Honey*

A continuous process for dehydrating honey. Victor A. Turkot, Roderick K. Eskew and Joseph B. Claffey.

A continuous process has been developed on a pilot-plant scale for producing dried honey. The product has color and flavor quite close to that of the original honey; has free-flowing, granular physical form; and has long shelf life. It can be produced from both table and baking grades of honey, either with or without the addition of sucrose before drying. Addition of sucrose raises the temperature at which the dried product will soften and makes it more resistant to caking at elevated temperatures. Honey essence of high potency and true aroma character can be



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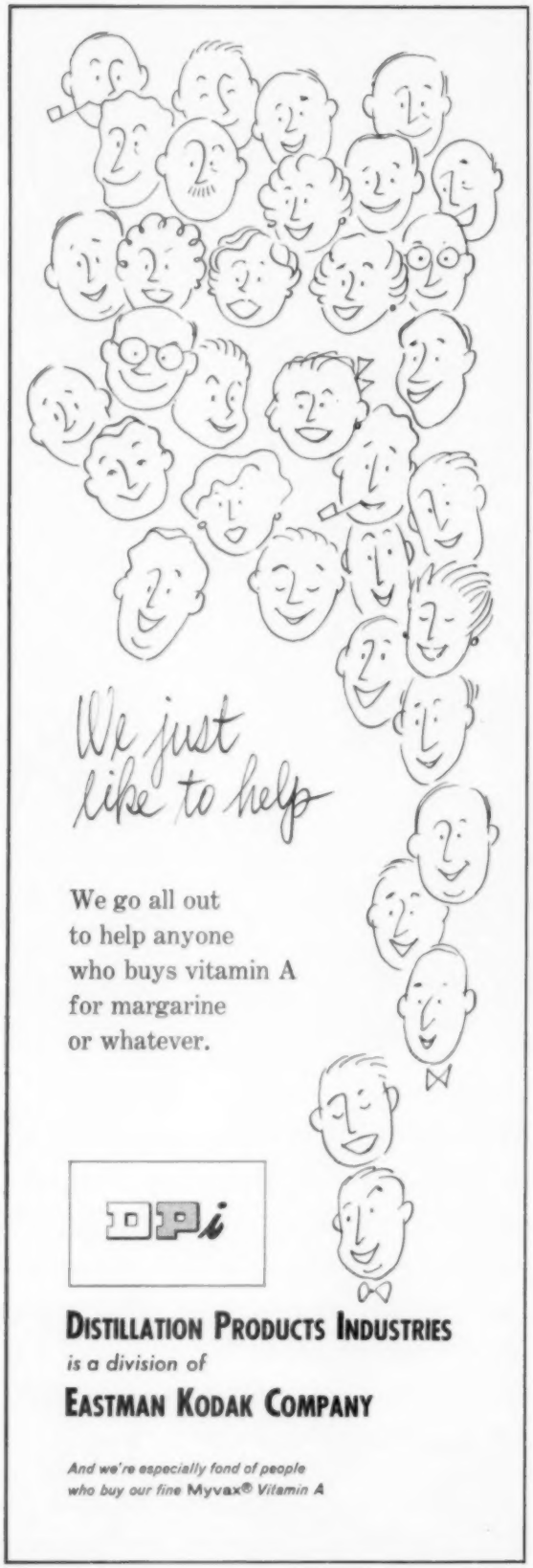
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obtained as a byproduct. Estimated costs of making the dried honey on a commercial scale are presented. The dried honey has applications in commercial baking, in confectionery making, and in the production of packaged dry baking mixes. (See page 387).

Freezing technology *Doughnuts*

Freezing, defrosting and frozen preservation of cake doughnuts and yeast-raised doughnuts. W. G. Bechtel and K. Kulp.

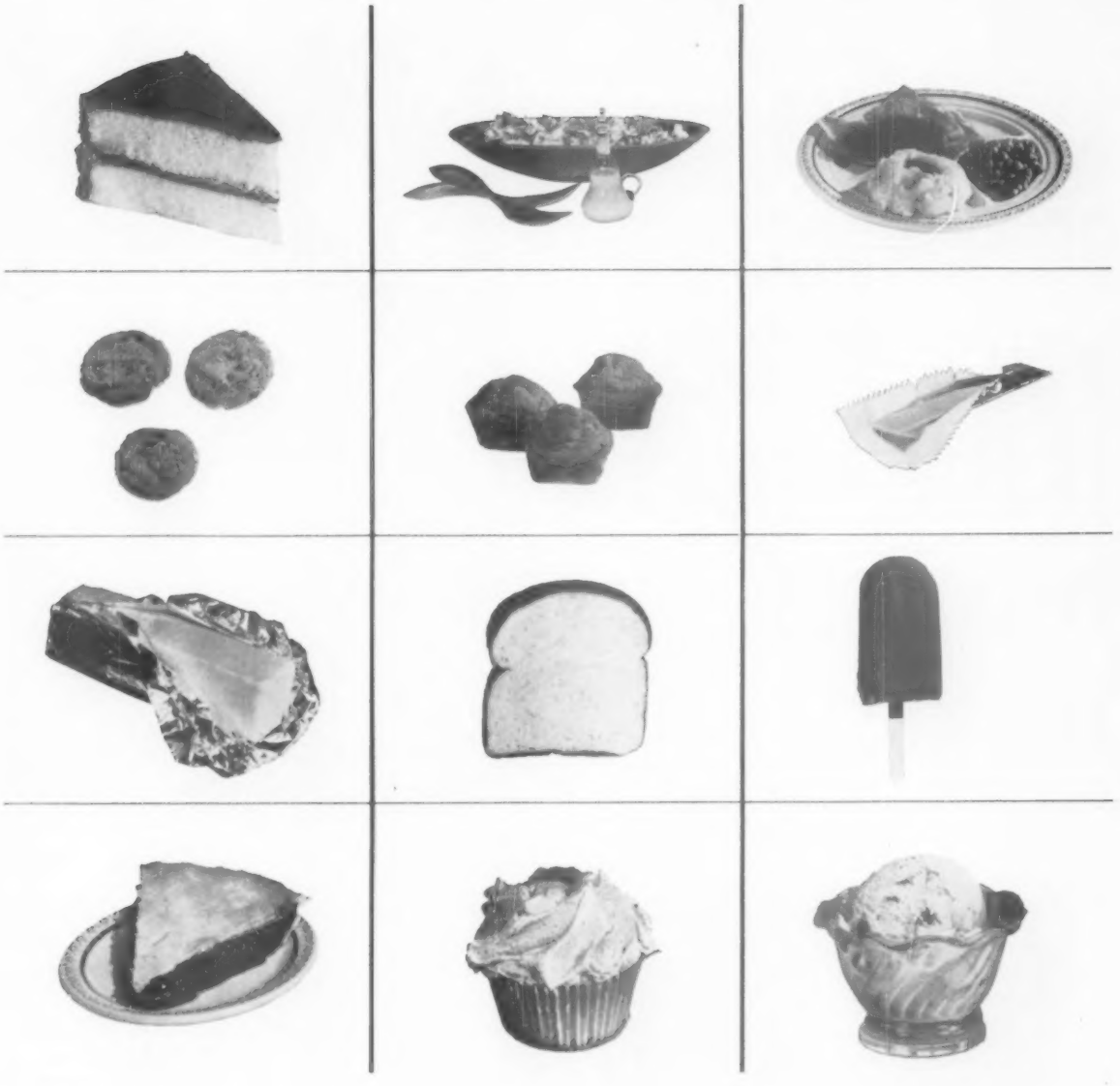
In freezing packaged doughnuts, forced air circulation at rates exceeding 500 linear feet per minute do not appear to produce additional benefits in lowered rate of freezing. For doughnuts to be stored at 0° F, freezer temperatures of −10° F or −20° F will materially lower the freezing time. There is a material gain in speed of defrosting through use of elevated temperature (115° F) and forced air circulation at 500 feet per minute. Freezing and defrosting lowered the freshness of doughnuts, but had far less effect than standing at room temperature for 24 hours. Within the limits employed, differences in freezing and defrosting time had only minor effects on freshness or firmness of doughnuts. If speed of freezing is of major importance, doughnuts may be frozen unwrapped with little moisture loss. Appreciable moisture loss occurs during defrosting of unwrapped doughnuts and this practice is not recommended. For frozen storage the temperature 0° F appears adequately low. Above this temperature doughnuts become stale and firm rather rapidly. (See page 391).

Radiation preservation *White potatoes*

The utilization of ionizing radiation to increase the storage life of white potatoes. M. Workman, M. E. Patterson, N. K. Ellis, and F. Heiligman.

Observations were made on sprouting, rate of decay and weight loss of 4 varieties of white potatoes exposed to 5, 7.5, 10.0, 12.5, and 15.0 kilorep of gamma radiation. Various curing treatments and dates of irradiation were also studied. Three experimental temperatures were used: 41°, 47°, and 55° F. Sprouting of Sebago, Russet Burbank and Katahdin potatoes stored at 41° F was prevented by 5.0 kilorep. The fourth variety, Red Pontiac, required 7.5 kilorep. At 47° F sprouting of all varieties was prevented with 7.5 kilorep. At 55°, Red Pontiac required 12.5 kilorep for complete inhibition although 10.0 and even 7.5 kilorep gave practical control. Sprouting of other varieties at 55° F was prevented by 7.5 kilorep. Irradiation reduced rate of weight loss in proportion to relative reduction in sprout growth. Hence the most spectacular results were at 55° F. Increasing the irradiation dose from 5.0 to 15.0 kilorep did not in general increase the decay rate. At 55° F intermediate dose levels of 7.5 and 10.0 kilorep gave slightly lower decay rates. Any curing treatment was beneficial but the most desirable seemed to be curing before irradiation. With the exception of the variety Sebago curing again following irradiation gave no additional benefit. Potatoes irradiated one, two or three months after harvest reacted similarly. Although irradiated potatoes remained quite free from decay for extremely long periods when not subjected to excessive handling (up

(Continued on page 23 following technical section)



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6. RELIABILITY OF SUPPLY
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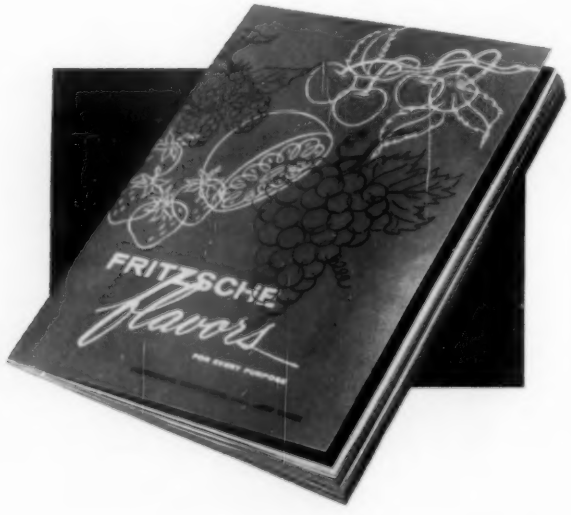

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The Effect of Added Levels of Sugar on Consumer Acceptance of Whole Kernel Corn

K. G. Weckel and Bruce Strong
University of Wisconsin
and
G. F. Garnatz* and Margaret Lyle
Kroger Food Foundation, Cincinnati

(Manuscript received March 1, 1960)

THERE IS LITTLE clear-cut knowledge available on the effect of levels of added sugar on consumer acceptance of canned whole kernel corn, and little of this type of information about other vegetable products. Buck and Weckel *(2)* revealed a preference for a higher level of sweetness than is now commonly found in commercially canned green beans. Other studies *(3–11)* have shown that the level of added sugar affects the degree of acceptance of fruit products and ice cream.

Selection of levels of added sugar in commercially canned whole kernel corn is generally guided by factors of cost, inherent sweetness and maturity of the corn, individual preference of the canners, and assumptions of what the market might prefer. A survey by the authors indicated that a considerable range of added sugar (40–80 lb/100 gal) was being used by commercial canners. A study was therefore undertaken to determine the consumer preference of levels of added sweetness in canned whole kernel corn in order to improve its acceptability.

A consumer panel of 250 families[a] in Madison, Wisconsin, and a panel of about 500 families located principally in the Midwest states,[b] and hereinafter referred to as the Madison, and Kroger panels, respectively, were utilized in the study.

METHODS

Preliminary studies were conducted to determine the probable upper and lower limits, and range between levels of sugar that could be used in canned whole kernel corn. The preliminary placement of range was accomplished by experimental packs of corn which were examined by both trained and untrained panels, and by experienced canners. Concentrations of sugar in the brine selected for the canned corn are presented in Table 1. The concentrations ranged from 3.0 to 8.7%. The variety Sugar King was selected for use in the study. Corn from one field was used to assure reasonable uniformity in quality. A total of 13,800 cans of corn was packed in the regular production line of a commercial cannery in one lb C enamel lined cans, vacuum packed and heat processed at 264° F for 10.5 min in a continuous A-B type retort. The corn was then stored at 40° F for 3 months to allow equilibration prior to distribution to the consumer panel.

Physico-chemical tests of the corn were made immediately after processing and at intervals during storage. Included were measurements of per cent salt, total solids, soluble, and alcohol insoluble solids, drained weight, pH, and color using a Hunter Color and Color Difference Meter. The effects of steam table treatment at 190° F for periods up to 6.5 hr on the color and pH of the corn also were measured. Representative samples of the canned corn were "unofficially" graded by U. S. Department of Agriculture graders.

Coded cans of whole kernel corn were distributed in pairs along with a printed questionnaire and instructions to members of the consumer panel. Participation was limited to persons 10 years of age and older. The questionnaire established the following: age, sex, preference of the pair for flavor, and preference of the pair for appearance. The questionnaire provided the judge opportunity to select a reason for preference of sample for flavor (sweeter, less sweet, normal, less salty, more salty) or for preference of sample for appearance (brighter, normal, darker). Provision was made in the questionnaire for "no difference" observations. The principle of Latin square arrangement was used in the distribution of the pairs of cans of corn. A given family was scheduled to receive 10 possible pair combinations of 20 cans of corn. Half of the cans of corn with a particular sugar level were marked "Red" while the other half were marked "Black." This enabled evaluation of the pairs in a reverse order by one-half of the consumers since all were directed to taste the can marked "Red" first. In the Madison tests each of the 10 pairs (includes those in reverse order) was presented in each of the 10 mailings so as to minimize bias due to the effect of storage. Each pair was presented to 26 families in each of the 10 mailings, providing a total of 260 family evaluations for each pair. Each Madison family examined each of the 10 pairs of samples. The same total distribution was made in a similar manner to the Kroger panel except that the corn was distributed to some 750 families rather than 250, and the responses then summarized. Each family did not receive all possible pairs of samples. A total of approximately 15,000 individual responses were received from the Madison and Kroger panels.

Contingency tables as described by Ostle *(2)* were used in the analysis of data to determine the effect of age, age and sex, and sex of the judges on their indicated preferences of the corn. The contingency tables provided the expected values which were subsequently used in the chi-square analysis to determine the significance values.

TABLE 1

Levels of sugar used in brine[1] added to canned corn for consumer acceptance evaluation

Code	Sugar	
	(lb/150 gal brine)	*(%, calculated)*
T	40	3.06
R	60	4.53
O	80	5.95
K	100	7.33
L	120	8.67

[1] A level of 22.5 lb salt/150 gal was used in each lot of brine.

RESULTS AND DISCUSSION

Changes in quality of the canned corn during storage at various temperatures is presented in Table 2. Effects of added sugar and of temperature and time of storage on the pH of the brine of corn appeared to be irregular; it was concluded that increasing the amounts of sugar was without significant effect on the

[a] Deceased, May 18, 1960.

[a] Distributed, approximately, as follows: 20% married students, 15% married office personnel, 30% married University faculty, and 35% skilled and unskilled labor.

[b] The panel of approximately 500 families was located principally in 6 Midwest States but limited distribution occurred in states bordering the Midwest. The term "Midwest" covers the principal distribution.

TABLE 2

Analyses of canned whole kernel corn

Period in storage		<24 hours					3 months					6 months				
Code		T	R	O	K	L	T	R	O	K	L	T	R	O	K	L
Sugar in put-in brine,[1] %		3.06	4.53	5.95	7.33	8.67	3.06	4.53	5.95	7.33	8.67	3.06	4.53	5.95	7.33	8.67
Salt in brine, %		1.80	1.76	1.84	1.87	1.89			.....			0.77	0.75	0.78	0.78	0.73
Soluble solids in brine (refractometer) %		6.6	8.5	11.3	13.6	16.0			.....			9.4	10.3	10.8	11.8	12.9
Total solids of drained corn							19.9	21.1	21.9	22.7	24.1					
A.I.S., %	40° storage						12.3	13.0	12.7	13.1	13.0					
	70° storage						13.0	13.3	12.7	13.1	13.0					
	90° storage						12.3	13.3	12.3	13.2	12.8					
pH of brine	40° storage						6.25	6.31	6.45	6.25	6.70	6.85	6.65	6.80	6.78	6.80
	70° storage						6.40	6.45	6.48	6.50	6.22	6.60	6.53	6.64	6.55	6.60
	90° storage						6.51	6.50	6.46	6.44	6.40	6.42	6.39	6.23	6.29	6.22
Drained weight, grams							314.8	.....	318.8	.....	319.2					
Grade[2]							A	A	A	A	A					

[1] Data represents measurements of 6 cans or more.
[2] "Unofficial" U.S.D.A. grade.

pH of the corn. The pH of brine of corn held on a steam table appeared to decrease slightly after 4.5 hr. Total and soluble solids of the corn increased as the amount of added sugar increased. During storage the higher initial levels of soluble solids in the corn decreased and the lower initial levels increased. Diffusion into or out of the corn kernel apparently occurred. Color differences of the corn packed and stored under different conditions were slight and appeared to be insignificant. A slight increase in hue and in intensity of color was noted as the amount of added sugar was increased. The red to yellow ratio tended to increase with the added sugar when the canned corn was stored at 90° F. The holding of the corn on the steam table appeared to be without significant effect on the color of the corn regardless of the level of added sugar. The A.I.S. did not appear to be affected by the level of sugar or storage conditions. The drained weight of the corn increased slightly as the amount of added sugar was increased.

An analysis was made of the summary of the responses of the consumer panels presented in Table 3.

TABLE 3

Preference evaluation of canned corn for flavor and appearance by consumer panels

Evaluation by consumer panels	Code				
	T	R	O	K	L
	Per cent sugar in put-in brine (calculated)				
	3.06	4.53	5.95	7.33	8.67
Appearance					
Madison					
No. of preferences	668	896	936	949	884
% of total	15.4	20.7	21.6	21.9	20.4
Kroger					
No. of preferences	539	600	712	823	811
% of total	15.4	17.2	20.4	23.6	23.3
Flavor					
Madison					
No. of preferences	708	1074	1200	1595	1498
% of total	11.6	17.7	19.7	26.3	24.7
Kroger					
No. of preferences	697	813	1095	1203	1361
% of total	13.5	15.7	21.2	23.3	26.3

Results show a significant preference of flavor and preference of appearance of the corn packed with the higher levels of added sugar. The flavor of corn with the two highest levels of added sugar (100–120 lb/150 gal brine) was judged by the Madison panel to be equally preferred and both were indicated significantly preferable to the corn containing lesser amounts of sugar. The preference was significant at the 1% level. The corn containing the four highest levels of sugar was judged by the Madison panel to be equivalent in appearance and was significantly preferred to the corn with lesser amounts of sugar. The flavor of corn with the highest level of added sugar (120 lb/150 gal brine), and the appearance of the corn with the two highest levels of sugar (100–120 lb/150 gal brine) were significantly preferred by the Kroger panel to the corn with lesser amounts of sugar. The preference was significant at the 1% level. The relation of age and sex to preference of flavor, and appearance, and of reasons for the preferences is presented in the data in Table 4. Although a few specific significant relationships were noted, no consistent trend was observed in the relation between age and sex and preference of corn with various levels of added sugar. Instructions for use of the corn presented to the University panel requested that it be simply heated and served without any additions of salt, pepper, or butter. Instructions presented to the Kroger panel provided for voluntary addition of condiment or butter. This may have had some effect upon the preference selection of certain age-sex groups.

SUMMARY

Within the range 3.0% to 8.7% sugar in the brine (equivalent to 40–120 lb/150 gal) added to canned whole kernel corn in 5 levels, there was a definite significant consumer preference of the highest levels. Because the data is self limiting, the acceptance of still higher levels of added sugar was not determined. It appears, however, that the maximum levels of acceptability of sweetness were approximately out-

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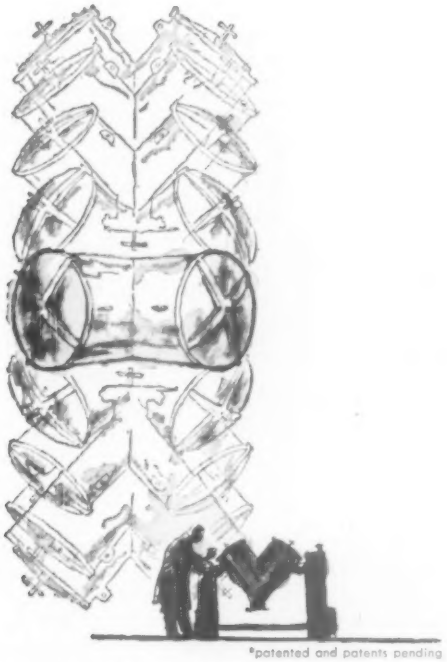

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Aluminum Foil Packaging– Prevention of Frozen Food Dehydration

One of a Series of Reports by Reynolds Metals Co.

"Freezer burn", a type of desiccation in frozen foods, is a serious problem facing packers, retailers and consumers alike. Resulting deterioration in quality, depending upon the degree of freezer burn, may include: objectionable appearance, irreversible dehydration of proteins, dryness and toughness in food tissues, and oxidation and rancidification of fats underlying dehydrated areas. The problem is particularly acute in products which tend to leave air-filled voids within a package, such as meats, poultry, fish, vegetables and certain prepared foods.

Laboratory tests show that package design and material can have a profound effect on this dehydration of frozen foods and that aluminum foil packaging offers exceptional protection.

Cut Moisture Loss

Aluminum foil packages have proved their ability to maintain contents at lower temperatures in transit and storage (See Reports No. 5 and No. 9). This indicated lower thermal energy content, of course, results in lower rates of evaporation or sublimation of contained moisture.

Dehydration is a serious factor even with frozen liquids which have no initial air spaces between product and package. As moisture is lost the product shrinks and leaves a space between itself and the package with subsequent further dehydration and oxidation. The extremely low water vapor transmission rate of aluminum foil packages is particularly effective for minimizing dehydration.

Besides protecting against voids caused by shrinkage, aluminum foil —with its ability to conform intimately to irregular shapes—can largely eliminate pockets of trapped air which occur in the packaging of large irregularly-shaped products such as poultry.

The higher thermal conductivity of aluminum provides more uniform and more rapid freezing. The uniformity of freezing reduces the possibility of localized warmer and colder areas within the product, which have been found to accelerate freezer burn. And the faster freezing results in the formation of smaller ice crystals which do not rupture food cells as readily as larger ones. This permits greater retention of moisture by the sound cells.

Halves Freezing Time

Fig. I shows the time required to reduce the temperature of packaged peas to 0°F in an air-circulated freezer at −10°F. Note that the contents of the aluminum foil package required approximately half as much time as the others to reach 0°F. In plate freezing, which is much faster, the same ratios of time are obtained. Fig. II illustrates in another way the ability of aluminum foil to reduce the dehydration of frozen foods. Because of vapor pressure differentials, frozen moisture tends to be drawn from the food itself and to form ice crystals within voids or cavities in the package. The graph shows the amount of this "cavity ice" formed in packaged frozen green beans stored at −10°F. It is to be noted that this formation, which is a measure of the dehydration, is greatest in the earlier months of storage and that it was two to three times as heavy in the non-aluminum packages.

For further information on this or any other phase of aluminum packaging protection, call your local Reynolds representative. Or write to **Reynolds Metals Company,** Richmond 18, Virginia.

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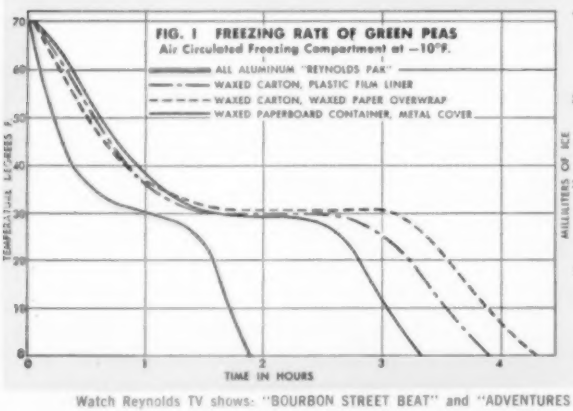
FIG. I FREEZING RATE OF GREEN PEAS
Air Circulated Freezing Compartment at −10°F.
ALL ALUMINUM "REYNOLDS PAK"
WAXED CARTON, PLASTIC FILM LINER
WAXED CARTON, WAXED PAPER OVERWRAP
WAXED PAPERBOARD CONTAINER, METAL COVER
TEMPERATURE DEGREES F.
TIME IN HOURS

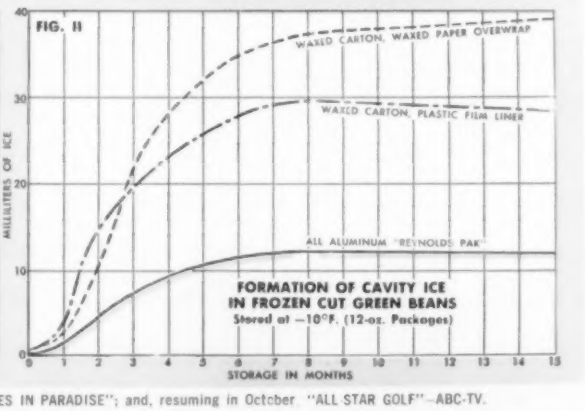
FIG. II
WAXED CARTON, WAXED PAPER OVERWRAP
WAXED CARTON, PLASTIC FILM LINER
ALL ALUMINUM "REYNOLDS PAK"
MILLILITERS OF ICE
FORMATION OF CAVITY ICE
IN FROZEN CUT GREEN BEANS
Stored at −10°F. (12-oz. Packages)
STORAGE IN MONTHS

Watch Reynolds TV shows: "BOURBON STREET BEAT" and "ADVENTURES IN PARADISE"; and, resuming in October, "ALL STAR GOLF"—ABC-TV.

TABLE 4

Results of evaluation of canned whole kernel corn by consumer panels

Major relationship	Panel	Number of sub-relationships	Number of sub-relationships statistically significant	Level of significance (%)	Age group where significant difference occurs
Sex vs Appearance	Madison	10	0	0	
	Kroger	10	0	0	
Sex vs Appearance (Reason)	Madison	6	0	0	
	Kroger	6	1	5	(Males)
Sex vs Flavor	Madison	10	0	0	
	Kroger	10	0	0	
Sex vs Flavor (Reason)	Madison	10	0	0	
	Kroger	10	1	1	(Males)
Age of Males vs Appearance	Madison	25	0	0	
	Kroger	25	0	0	
Age of Males vs Appearance (Reason)	Madison	15	2	1	(25–39) + (60)
	Kroger	15	0	0	
Age of Males vs Flavor	Madison	25	1	1	(60>)
	Kroger	25	1	1	(16–24)
Age of Males vs Flavor (Reason)	Madison	25	1	1	(25–39)
	Kroger	25	1	1	(16–24)
Age of Females vs Appearance	Madison	25	1	5	(60>)
	Kroger	25	2	1	(<16) + (60>)
Age of Females vs Appearance (Reason)	Madison	15	1	1	(<16)
	Kroger	15	0	0	
Age of Females vs Flavor	Madison	25	0	0	
	Kroger	25	3	2	(40–59–60)–1%;
				1	(25–39)–5%
Age of Females vs Flavor (Reason)	Madison	25	1	1	(<16)
	Kroger	25	0	0	
Age of Males and Females vs Appearance	Madison	25	0	0	
	Kroger	25	1	5	(25–39)
Age of Males and Females vs Appearance (Reason)	Madison	15	2	1	(<16) + (25–39)
	Kroger	15	1	1	(<16)
Age of Males and Females vs Flavor	Madison	25	0	0	
	Kroger	25	1	1	(16–24)
Age of Males and Females vs Flavor (Reason)	Madison	25	0	0	
	Kroger	25	0	0	

lined and determined. These levels of preference of sweetness are on the average greater than is presently being used in the commercial canning of whole kernel corn. There does not appear to be any consistent effect of age or sex on preference of level of sweetness of the canned corn.

Use of increased levels of added sugar in the canned corn results in an increase in soluble and total solids of the corn, but is without effect on alcohol insoluble solids as measured for grading purposes. Use of increased levels of sugar in the canned corn is without significant effect on the steam table tolerance of the corn.

Acknowledgment

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Organic Acids in the Apple as Related to Variety and Source*

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(Manuscript received April 13, 1960)

PRIOR TO 1950, according to Hulme *(7)*, most studies of acid changes in fruits were confined to measuring titratable acidity, generally expressed in terms of malic acid equivalents. However, presence of acids other than malic has been known for many years. The first such acid was identified as citric acid by Bryan *(1)* in 1946. Other identifications followed and in 1958 Hulme *(7)* reported that 29 different acids may be present in the apple on the basis of work done up to that time.

Previous studies concerned with acid composition of the apple have dealt with such identifications for a given sample without comparisons for varieties and location. The purpose of this study was to compare the acid composition of the apple as related to variety and source.

EXPERIMENTAL

Harvesting and preparation procedures. Mature apples from Michigan and Washington were used. The varieties were McIntosh, Golden Delicious, and Red Delicious from Michigan, and Golden Delicious from Washington. Immediately after harvest, the fruits were shipped to East Lansing and, as received, placed in a 0° C (32° F) storage.

After a short period of storage, samples were taken from each lot of fruit and placed in respiration chambers at 24° C (75° F) to determine the rate of CO_2 evolution [Claypool *et al (4)*]. In 1955, a CO_2 evolution of 30 mg of CO_2 per kg of fruit for 1 hr was selected as the most desirable stage for preparing fruit samples for analyses. The number of days required to reach this value was determined in the respiration chambers, and the fruit removed from storage for the required period of time prior to preparing samples for analysis. Pressure tests were made on another sample employing a Magness-Taylor pressure tester *(9)* using a 7/16 in plunger.

Longitudinal slices of McIntosh, Red Delicious, and Golden Delicious were prepared from the fresh, mature apple samples described above. The sample included the skin and flesh but excluded the core. These slices (350–400 g) were mixed in a Waring blender for approximately 3 min at room temperature to obtain a smooth slurry. The slurry was rapidly chilled to 0° C (32° F) to prevent browning and then filtered at 0° C through Whatman No 12 folded filter paper. The juice obtained from each sample was heated on a steam bath for 20 min to inhibit enzyme activity. A soluble solids test was run on the juice extract with a Bausch & Lomb hand refractometer; and the dry weight of the pulp was determined after drying in a forced draft oven at 60° C (140° F) for 72 hr.

Chromatographic separation. The juices from the 4 apple samples were fractionated by use of silicic acid chromatographic columns. Each column was made of pyrex pipes, 4 cm I.D. and 90 cm long, equipped with ball and socket joints and 3-way stop cocks. They were connected to a single tank of nitrogen as a pressure source. Each of the 4 columns contained 200 g of silicic acid and were packed to a uniform density by employing 1 to 2 lb psi of nitrogen gas.

A 12 ml aliquot of the juice from the samples was added to the column by the method of Wise *(11)* and fractionated according to the procedures of Marvel and Rands *(8)* and Buch *et al (3)*. The developing solvents were passed through the columns at the desired rate by use of pressure applied with nitrogen gas. The first solvent system was water saturated chloroform. It was made more polar by adding increments of n-butanol until a water saturated butanol system was obtained. A final mixture of 3 volumes of water saturated 50–50 chloroform/butanol plus one volume of absolute ethanol was used to remove the last trace of acids.

By this method, 140 fractions of 100 ml each were collected from each column. The presence of acids in each fraction was determined by titrating a 10 ml aliquot with 0.0153 *N* NaOH after the addition of phenol red indicator and sufficient ethanol to produce a single phase. Total acidity was calculated by adding the acidities of each titration peak or fraction. Titration of a 12 ml aliquot of the original juice showed an average recovery of 107.3% of the titratable acidity with a standard deviation of ±.005 meq/ml of extracted juice.

Identification of acids. Each 100 ml fraction found to contain acids was concentrated to dryness by vacuum distillation at 30° C (86° F) using a rotary vacuum apparatus. After drying, the fractions were dissolved in 2.0 ml of water or 95% ethanol and rechromatographed by use of uni-dimensional, ascending paper chromatography. A 0.05 ml aliquot of the sample was applied to Whatman No 1 filter paper. The solvent system of Palmer *(10)*, containing diethyl ether, 88% formic acid and water in 5:2:1 proportions, was used. The chromatograms were sprayed with 0.04% solution of bromophenol blue in 95% ethanol adjusted to pH 5.8. Amino acids were detected by spraying the chromatograms with ninhydrin reagent. For identification a total of 74 acids were used—56 organic and 18 amino acids.

RESULTS

As shown in Table 1, the Red Delicious variety had the highest, and the Golden Delicious from Washington had the lowest pressure test. The Golden Delicious and McIntosh from Michigan were intermediate in firmness. Soluble solids content was highest for Golden Delicious and lowest for McIntosh.

Per cent dry weight was highest for Red Delicious and Golden Delicious from Michigan, and lowest for McIntosh. The juice to pulp ratio was highest for McIntosh and lowest for Red Delicious and Golden Delicious from Michigan.

Golden Delicious from Michigan had the highest initial rate of CO_2 evolution and, paradoxically, the lowest terminal rate

TABLE 1

Pressure tests, soluble solids, and dry weights of samples used for acid analysis[1]

Source	Pressure test	Soluble solids	Dry weight	Juice yield
	(in lbs)	(%)	(%)	(%)
Michigan				
McIntosh	10.3	11.6	16.3	20
Red Delicious	14.9	13.8	19.0	13
Golden Delicious	12.1	15.0	19.0	12
Washington				
Golden Delicious	8.9	14.5	17.8	18

[1] Averages of three replications. Pressure tests were taken prior to analysis.

* Published as Journal Article No. 2598 from Michigan Agricultural Experiment Station.

TABLE 2

Rate of CO_2 evolution from the apple samples for eleven days at 24° C (75° F) mg CO_2/kg fruit for one hour

Days	Michigan		Washington	
	McIntosh	R. Delicious	G. Delicious	G. Delicious
1	30.7	32.5	40.8	35.9
2	25.3	29.9	32.7	32.1
3	21.4	29.8	26.0	27.8
4	20.4	28.6	24.8	26.9
5	24.5	31.8	28.2	25.4
6	23.2	29.3	24.9	24.2
7	21.6	27.4	22.8	22.3
8	21.3	27.1	21.4	21.2
9	19.7	25.0	19.7	19.5
10	20.3	24.8	19.6	19.3
11	19.9	23.8	18.7	18.9

of evolution after 11 days at 24° C (75° F). The McIntosh apples had the lowest initial rate of CO_2 evolution. Red Delicious apples from Michigan had the highest terminal rate of CO_2 evolution (See Table 2).

Marked differences were found in total acidity. Michigan Golden Delicious had the highest total acidity—.064 meq/ml of extracted juice; followed by Michigan McIntosh—.062 meq/ml; Washington Golden Delicious—.027 meq/ml; and Michigan Red Delicious—.023 meq/ml. In Figures 1, 2, 3, and 4, the peaks are shown for each variety tested. The peaks in each variety were dissimilar. For example, when Figures 3 and 4 are compared, the Michigan Golden Delicious revealed an entirely different group of acids from Washington Golden Delicious. It was interesting that the largest acid peaks for the Washington Golden Delicious and Red Delicious from Michigan were not malic.

Table 3–6 give the possible identity of acids contained in the effluent of the silicic acid column. The Rf is shown for the fruit unknown on Whatman No 1 paper. The Rf value differed slightly for each chromatogram. Therefore, it was necessary to have some of the fruit unknown spotted with the known acid on the same paper, under identical conditions.

Red Delicious (Figure 1, Table 3) showed only 6 separate acid peaks but 7 acids. Two came through the column in fraction 108. Fraction 79 would appear to be malic but paper chromatography did not substantiate this assumption. The acids present had chromatographic properties similar to citric, m-tartaric, and a ninhydrin positive acid, suggesting an amino acid. Another unidentified napthoresorcinol positive, uronic acid was present but was not similar to galacturonic.

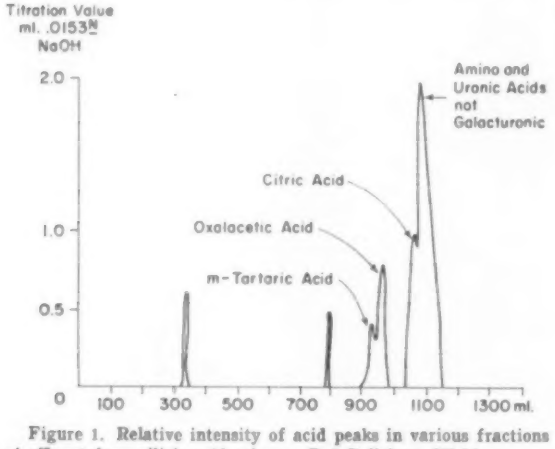

Figure 1. Relative intensity of acid peaks in various fractions of effluent from silicic acid column. Red Delicious, Michigan.

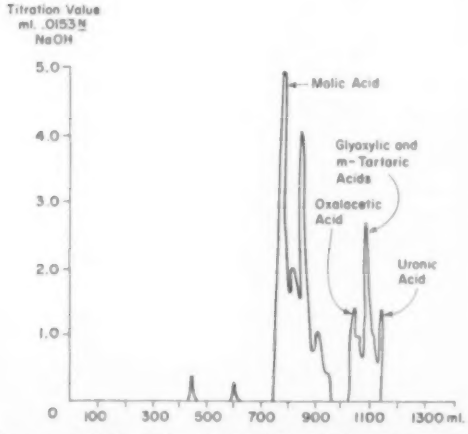

Figure 2. Relative intensity of acid peaks in various fractions of effluent from silicic acid column. McIntosh, Michigan.

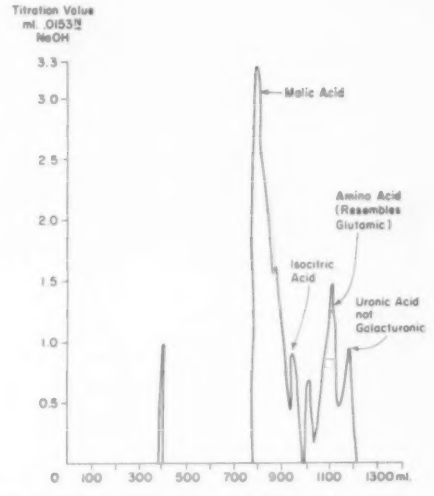

Figure 3. Relative intensity of acid peaks in various fractions of effluent from silicic acid column. Golden Delicious, Michigan.

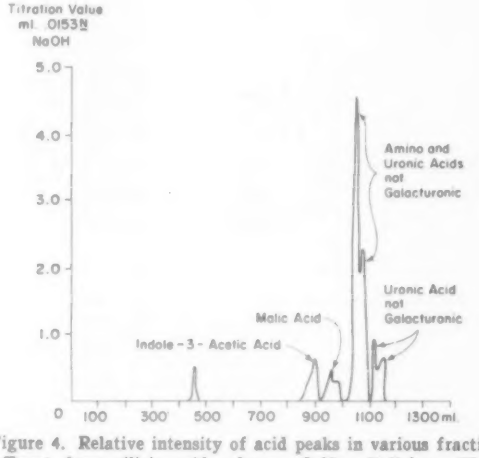

Figure 4. Relative intensity of acid peaks in various fractions of effluent from silicic acid column. Golden Delicious, Washington.

TABLE 3

Fractions containing acids obtained from Red Delicious, Michigan, and possible identity by paper chromatography

Michigan Red Delicious	Ether-formic acid-water 5 : 2 : 1	
Fraction	Rf × 100	
	Unknown	Known
34	*	
79	33	.....
93	59	m-tartaric acid—58
96	30	oxalacetic acid—29
104	57	citric acid—56
108	39 & 52+	an amino acid—39 and uronic acid—52

* Acids were apparently too labile to detect by paper chromatography.

TABLE 4

Fractions containing acids obtained from McIntosh, Michigan, and possible identity by paper chromatography

Michigan McIntosh	Ether-formic acid-water 5 : 2 : 1	
Fraction	Rf × 100	
	Unknown	Known
44	27	.....
60	83	.....
79	51	Malic acid—52
81	26	.....
85	59	.....
90	48	.....
104	30	Oxalacetic acid—30
108	26 & 51	Glyoxylic acid—26 and m-tartaric acid—51
114	32	A uronic acid

McIntosh (Figure 2, Table 4) had 9 different peaks, suggesting 9 different acids. However, there were 10 acids as two came through the column in fraction 108. The ones that were identified had chromatographic properties similar to malic acid, oxalacetic acid, glyoxylic acid, m-tartaric acid, and a uronic acid that gave a positive napthoresorcinol test but was not similar to a galacturonic acid.

Michigan Golden Delicious (Figure 3, Table 5) gave 7 acid peaks when titrated with base. Acids similar to malic, isocitric, and glutamic acids were noted. The same unknown uronic acid found for Red Delicious and McIntosh was present in the effluent. It was not similar to galacturonic acid.

TABLE 5

Fractions containing acids obtained from Golden Delicious, Michigan, and possible identity by paper chromatography

Michigan Golden Delicious	Ether-formic acid-water 5 : 2 : 1	
	Rf × 100	
Fraction	Unknown	Known
40	*	
78	56	Malic acid—55
86	39	.....
94	57	Isocitric acid—58
100	59	.....
111	42	Glutamic acid—41
118	49	A uronic acid

* Acids were apparently too labile to detect by paper chromatography.

TABLE 6

Fractions containing acids obtained from Golden Delicious, Washington, and possible identity by paper chromatography

Washington Golden Delicious	Ether-formic acid-water 5 : 2 : 1	
Fraction	Rf × 100	
	Unknown	Known
46	*	
86	94	Indole-3-acetic acid—94
94	64	Malic acid—63
104	58 & 56	Uronic acid—58 and amino acid—56
108	58 & 56	Uronic acid—58 and amino acid—56
112	53	Uronic acid
116	58	Uronic acid

* Acids were apparently too labile to detect by paper chromatography.

Washington Golden Delicious (Figure 4, Table 6) also gave 7 acid peaks. The ones identified had chromatographic properties similar to indole-3-acetic acid, malic, a uronic acid not similar to galacturonic, and an amino acid.

DISCUSSION

Results of this study show marked differences in both the amount and kind of organic acids found in different varieties of apples. Also, there appeared to be differences in the organic acids found in a given variety from different locations.

There were several acid peaks obtained from the silicic acid column that were not identified by paper chromatography. The following acids used in this study have been reported [Davis *(5)*, Hulme *(6)*, Hulme *(7)*, Bryant and Overell *(2)*, and Bryan *(1)*] to occur in apples: chlorogenic, citramalic, galacturonic, glyoxylic, glycerie, isocitric, 2-ketogluconic, lactic, malic, oxalacetic, pyruvic, shikimic, succinic, aspartic, cystine, glutamic, leucine, L-proline, serine, threonine L-tryptophane, and valine. Only four of these were found in the apple samples studied. Malic acid was found in all samples except for Michigan Red Delicious. In addition, two unreported fruit acids, m-tartaric and indole-3-acetic, were found. Also, other amino and uronic acids were present in all samples but could not be identified. In one sample the unidentified amino acid resembled glutamic and a uronic acid was found that was different from galacturonic according to the Rf value.

The differences found in this study between different lots and varieties of apples were interesting. Varietal differences may be assumed to be genetic in origin. However, differences within a variety, as shown for the Golden Delicious variety, may be assumed to be due to environment. Environmental differences for the two Golden Delicious samples were both climatic and nutritional. However, environmental differences would be slight for the three varieties from Michigan since they were collected from the same orchard.

At this time, it is only possible to speculate as to which of these factors (genetic, climatic, and nutritional) have the greatest influence. However, it is

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apparent that genetic, climatic, and nutritional factors all influence the total acidity of apples and the relative proportions of acids combined into the total acidity of apples. In addition, it is possible to suggest that these genetic, climatic, and nutritional variations created a metabolic-enzymatic environment that cause the respiratory products to differ and be reflected in the kinds and total amounts of acids found in the different samples. These studies reflect such differences as they may occur during the post climacteric stages of the apple. The existence of similar differences during the growth period would require additional studies.

SUMMARY

Three apple varieties, McIntosh, Red Delicious, and Golden Delicious, were studied in regard to organic acid composition. Two lots of Golden Delicious were used—one from Michigan and one from Washington. The McIntosh, Red Delicious and Golden Delicious samples were from the same orchard in Michigan.

The four lots of apples were compared as to pressure test, soluble solids, per cent dry weight, rate of CO_2 evolution and the per cent of juice. Marked differences in these factors were found and may reflect genetic, or environmental factors which in turn would influence the acid composition.

Total acidity was highest for the Michigan Golden Delicious and lowest for the Washington Golden Delicious. Acids having chromatographic properties similar to the following acids were found for each lot of apples:

Michigan

McIntosh—malic, oxalacetic, glyoxylic, m-tartaric, and a uronic acid.

Red Delicious—m-tartaric, oxalacetic, citric, an amino acid and uronic acid.

Golden Delicious—malic, isocitric, glutamic, and a uronic acid.

Washington

Golden Delicious—indole-3-acetic, malic, an amino acid and two uronic acids.

Acknowledgments

The authors wish to express their sincere gratitude to Drs. H. M. Sell and Selma Bandemer, Department of Agricultural Chemistry, Michigan State University, Dr. Margaret L. Buch, Eastern Regional Laboratory, Philadelphia, Pa., Dr. A. Van Doran, Tree Fruit Experimental Station, Wenatchee, Washington, and the National Apple Institute for assistance in various phases of this investigation.

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Changes in Protein Extractability During Post-rigor Tenderization of Chicken Breast Muscle[a]

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(Manuscript received February 29, 1960)

POST-RIGOR CHANGES associated with increasing tenderness of beef have been widely studied for many years, and the need for "aging" of other meats has also been recognized *(2, 7)*. Post-rigor tenderization of poultry is particularly rapid and extensive during the first few hours after slaughter *(9, 14)*.

Extensive biochemical and histological studies have been carried out on chicken muscle *(5)* and on beef *(6, 17)*, but the mechanism of the post-rigor tenderization is not well understood. Attempts to obtain experimental data for beef would be inconclusive, as progressive autolysis and the action of microbial enzymes will introduce extensive unrelated changes. However, in chicken, tenderization occurs rapidly and these unrelated changes would not interfere to the same extent. Changes in the extractability of the contractile proteins from pre- and post-rigor chicken breast muscle were therefore studied.

METHODS

Four to 8 months' old chickens were slaughtered by severance of the neck veins, bled, scalded at 54° C for 2 min, and plucked and eviscerated by hand. Within 30 min after death of the bird a pre-rigor 10-g sample of *pectoralis major* muscle was excised and ground with 15 g of sand and 15 to 20 ml of phosphate buffer (pH 7.5) in 0.4 M potassium chloride [total ionic strength ($\frac{\Gamma}{2}$) 0.55] in a mortar. Grinding required about 5 min, and tests showed that within reasonable limits the vigor with which the grinding was carried out had only a minor effect on the amount of protein extracted. The paste thus obtained was transferred to a volumetric flask, made to 100 ml including sand and muscle solids, and then centrifuged at about 750 × g for 15 min.

Post-rigor samples were removed from the carcass about 24 hr later and treated in the same manner. For some tests samples taken pre-rigor were ground, diluted to volume, and the extraction continued for 24 hr with agitation at 2° C.

Aliquots of the supernatants from these extracts were analysed and fractionated by the following procedures:

1. Total nitrogen. All nitrogen determinations were done by a microkjeldahl procedure using a mercury catalyst.
2. Non-protein nitrogen. Protein nitrogen was precipitated with 12.5% trichloracetic acid and the filtrate analysed.
3. Non-dialysable or protein nitrogen. The extracts were dialysed for 24 hours against phosphate-KCl buffer, pH 7.5, total $\frac{\Gamma}{2} = 0.40$, and the dialysand analysed.
4. Nitrogen soluble at $\frac{\Gamma}{2} = 0.225$. The dialysand from the above dialysis was either diluted, or dialysed against buffer of the appropriate ionic strength, then centrifuged at about 1000 × g for 30 min. The difference between this value and the non-dialysable nitrogen is reported as "actomyosin" nitrogen.
5. Nitrogen soluble at $\frac{\Gamma}{2} = 0.05$. The supernatant from the above procedure was again diluted or dialysed. The difference between this value and the nitrogen soluble at $\frac{\Gamma}{2} = 0.225$ is reported as "myosin" nitrogen.

Electrophoresis was carried out with a Spinco Model H apparatus, with standard 11 ml cells, at 16 mamp for up to 20 hr.

EXPERIMENTAL

Extracts prepared rapidly from pre-rigor muscle were slightly cloudy, but only moderately viscous. Those prepared from post-rigor muscle, and also those prepared by 24 hr extraction of pre-rigor samples, were extremely cloudy and viscous to the point of being almost gelationous. The total nitrogen content of extracts from pre-rigor muscle ranged from 2.87 to 3.35 (av for 9 birds, 3.19) mgm/ml, while that of the post-rigor extracts ranged from 3.51 to 4.04 (av 3.79) mgm/ml. The average extraction of protein (exclusive of non-protein nitrogen) was 76% pre-rigor, 90% post-rigor.

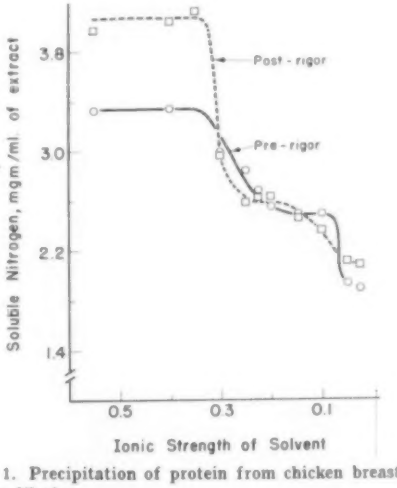

Figure 1. Precipitation of protein from chicken breast muscle extracts by dilution.

Precipitation of protein during dilution of the extracts occurred in two steps (Figure 1), the first presumably representing precipitation of "actomyosin", the second "myosin". Precipitation of "actomyosin" was complete at $\frac{\Gamma}{2} = 0.25$ to 0.20, and a value of $\frac{\Gamma}{2} = 0.225$ was selected as the most suitable for this separation. Precipitation of "myosin" was complete at $\frac{\Gamma}{2} = 0.05$.

The curves of Figure 1 indicate a greater "actomyosin" content in the post-rigor extract, and this was confirmed in other tests (Table 1). "Myosin" nitrogen, on the other hand, was higher in pre-rigor than in post-rigor extracts (Table 1). Neither the nitrogen soluble at ionic concentration 0.05 nor the non-protein nitrogen were significantly altered by post-slaughter tenderization of the muscle.

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[a] Contribution from the Division of Applied Biology, National Research Council, Ottawa, Canada. Issued as N.R.C. No. 5752.

[b] Present address: Canada Packers Limited, Toronto, Canada.

TABLE 1

Nitrogen distribution in extracts (all values as mgm/ml extract)

Total nitrogen	"Actomyosin" nitrogen	"Myosin" nitrogen	Non-protein nitrogen	Nitrogen soluble at $\frac{\Gamma}{2} = 0.05$
Pre-rigor extracts—KCl buffer				
3.23	0.38	0.80	0.67	1.38
3.22	0.56	0.61	0.73	1.32
3.11	0.41	0.49	0.77	1.44
3.29	0.53	0.82	0.70	1.24
Av 3.21	0.47	0.68	0.72	1.35
Post-rigor extracts—KCl buffer				
3.75	1.70	0.09	0.67	1.29
3.61	1.19	0.36	0.71	1.35
3.87	1.57	0.31	0.81	1.18
Av 3.74	1.49	0.25	0.73	1.27
Pre-rigor extract—KI buffer				
3.50	0.01	0.86	1.03	1.60
Post-rigor extract—KI buffer				
3.69	−0.07	1.18	0.96	1.62

Extraction with phosphate buffer in 0.4 M potassium iodide instead of potassium chloride confirmed the suggestion *(16)* that iodide causes dissociation of actin and "actomyosin". However, these extracts (Table 1) contained more nitrogen soluble at $\frac{\Gamma}{2} = 0.05$, and more non-protein nitrogen, than did extracts made with potassium chloride buffer, and this would indicate that there had been considerable breakdown of the contractile proteins into smaller fragments. Further tests with potassium iodide were therefore not undertaken.

Dilution of the initial extracts by addition of 4 volumes of phosphate-potassium chloride buffer and centrifugation at 78,000 × g for 2 hr (Spinco Model L, No. 30 rotor) removed a fraction which was similar in amount and in its effect on turbidity and viscosity to the "actomyosin" fraction of either pre- or post-rigor extracts. Sedimentation of actomyosin at 78,000 × g indicates that under these conditions it existed in an agglomerated form.

Attempts were made to determine the amounts of "actomyosin" and "myosin" in these extracts by electrophoresis. The high turbidity and viscosity prohibited electrophoresis of post-rigor extracts; addition of potassium iodide reduced the viscosity but was unsatisfactory for the reasons discussed above. The expected patterns were obtained for total pre-rigor extract (Figure 2A) and for the protein soluble at $\frac{\Gamma}{2} = 0.225$ (i.e. total extract less "actomyosin") (Figure 2B). The mobility of the leading boundary, which separated into two peaks in the ascending pattern of the "total" extract, corresponded to that of actomyosin and myosin *(1)*. Separation of the actomyosin and myosin only occurred at the ascending boundary and was never clear enough to permit quantitative estimation. The absence of any separation after dilution to $\frac{\Gamma}{2} = 0.225$ cannot be taken as proof that all of the actomyosin had been removed. Assuming that the relative areas under the peaks are proportional to the nitrogen content, 0.38 mgm N/ml were precipitated from the "myosin-actomyosin" peak, 0.17 mgm/ml from the slower peak.

The "actomyosin" and mixed "actomyosin" plus "myosin" precipitates could not be redissolved in KCl-phosphate buffer. "Actomyosin" precipitated from these extracts with ammonium sulphate *(3)* was also insoluble in KCl-phosphate buffer.

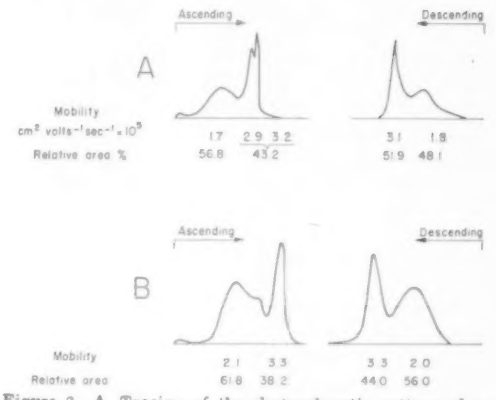

Figure 2. A. Tracing of the electrophoretic pattern of a pre-rigor extract of chicken breast muscle, $\frac{\Gamma}{2} = 0.40$, pH 7.5, nitrogen 2.4 mgm/ml, electrophoresis for 16.2 hr; mobility and area data are averages of 4 runs.

B. Tracing of the electrophoretic pattern of supernatant solution from the precipitation of "actomyosin", $\frac{\Gamma}{2} = 0.40$, pH 7.5, nitrogen 1.93 mgm/ml, electrophoresis for 21.3 hr; mobility and area data are averages of 2 runs.

Stepwise dilution of either pre- or post-rigor extracts yielded a "myosin" precipitate that could be redissolved and subjected to electrophoresis (Figure 3). The solution thus prepared apparently contained two components, the faster moving having the mobility of myosin. In agreement with the dilution precipitation results, the amount of this myosin component was much higher in precipitate prepared from pre-rigor extracts than from post-rigor extracts. However, the dilution technique obviously precipitated additional protein, and the true amount of myosin present in pre- and post-rigor extracts was probably about 64 and 20%, respectively, of that shown in Table 1.

The supernatant solution (dialysed back to $\frac{\Gamma}{2} = 0.40$) obtained by dilution of the extract to $\frac{\Gamma}{2} = 0.05$ gave a single broad electrophoretic boundary that tended to spread without separation into clear peaks.

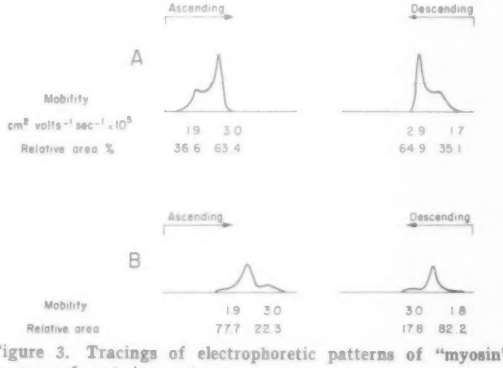

Figure 3. Tracings of electrophoretic patterns of "myosin" from pre- and post-rigor extracts.

A. Pre-rigor, $\frac{\Gamma}{2} = 0.40$, pH 7.5, nitrogen 0.20 mgm/ml, electrophoresis for 18.3 hrs, single run.

B. Post-rigor,, $\frac{\Gamma}{2} = 0.40$, pH 7.5, nitrogen 0.09 mgm/ml, electrophoresis for 14.6 hrs; mobility and area data are averages of 3 runs.

DISCUSSION

It is generally assumed that post-rigor tenderization involves "autolysis", and many researchers probably agree with the warning *(2)* to avoid the "morass of autolysis". However, tenderness is one of the most important quality factors for meats of all types, and a reaction that can improve tenderness in poultry approximately 4-fold within a few hours *(9, 14)* at 0° C is worthy of considerable study. Increases in low molecular weight nitrogenous compounds formed by tissue decomposition were detectable after 14 days in chilled poultry *(5)*, but must have been completely insignificant during the first few hours. Moreover, most of the autolytic products were formed from proteose and peptone fractions, rather than from proteins *(5)*, so would not significantly affect tenderness of the sample. Most probably a relatively specific cleavage of contractile muscle components is involved in tenderization. Erdos *(4)* has suggested that "the relaxation of rigor mortis is caused by a disorganization, i.e., the release of actin from the structure," and Szent-Gyorgyi *(15)* believes that tenderization with aging involves "the disintegration of the actin filaments."

A study of extracts does not give unequivocal evidence as to the state of the muscle proteins at the time extraction began. In rigor the contractile protein is considered to be present as the "actomyosin" complex, and it is possible that dissociation of this complex into actin and myosin contributes to tenderization. Wierbicki *(18)* found no evidence for this dissociation, and while the present work shows an increase in "actomyosin" in post-rigor extracts, the complex may have reformed in the extract; therefore no conclusion can be reached as to the degree of post-rigor dissociation of "actomyosin".

The increase in "actomyosin" and decrease in free "myosin" in post-rigor as compared to pre-rigor extracts suggests that there has been an increase in the amount of actin extracted. The average values of Table 1 show an increase in "actomyosin" nitrogen of 1.02 mgm/ml, which is accounted for by a shift of 0.43 mgm/ml of "myosin" nitrogen to the "actomyosin" form, plus extraction of 0.53 mgm/ml additional nitrogen. Since actin combines with 2 to 4 times its weight of myosin *(8, 16)*, all of the additional nitrogen extracted could not be actin and still leave free myosin in the extract. Additional "myosin" or "actomyosin" must therefore have been extracted post-rigor.

Besides reacting to form actomyosin, actin contributes to the structure of the myofibrils by associating either with itself or with some other protein to form filaments *(12)*, and the strength of this association probably varies along the length of the myofibril *(11)*. A decrease in the strength of this association so as to permit a greater extraction of actin from post-rigor than from pre-rigor muscle (followed by formation of actomyosin in the extract) would explain the results obtained in the present study and would be in accord with the suggestions of Erdos *(4)* and Szent-Gyorgyi *(15)*. Such a release of actin would render the muscle more tender by weakening the muscle fibres, and would account for the fibre breakages observed by histological means *(5, 10)*.

SUMMARY

Pectoralis major muscles of young chickens were extracted with phosphate-potassium chloride buffer, pH 7.5, ionic concentration 0.55, and the extracts fractionated by dilution to lower ionic concentrations.

The amount of nitrogen extracted increased when the carcasses were held for 24 hr at 4° C, and this increase was entirely accounted for by an increase in the "actomyosin" fraction. Since less free "myosin" was present in post-rigor than in pre-rigor extracts, despite an increase in total "myosin" plus "actomyosin", it is suggested that more actin was extracted from post-rigor meat and that this actin combined with "myosin" in the extract. More "myosin" or "actomyosin" was also extracted post-rigor.

It is suggested that tenderization is not merely random autolysis but results from a specific cleavage of an actin association responsible for the maintenance of the muscle matrix.

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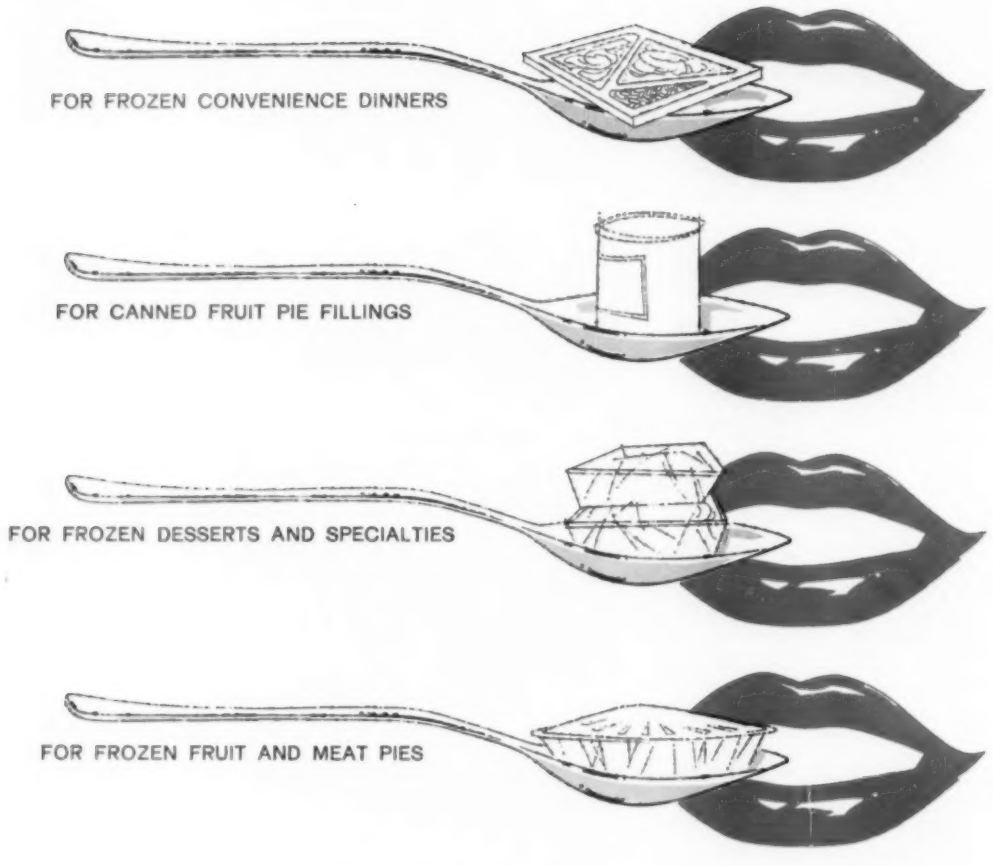
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Irradiation Preservation of Pacific Northwest Fish. I.

Cod Fillets

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(Manuscript received March 10, 1960)

Numerous studies are reported in the literature on the preservation of various foods by ionizing radiation, but relatively little information is published on fishery products and on Pacific Coast fish in particular. Nickerson, Goldblith, and Proctor *(6)* used cathode rays to destroy the bacteria in mackerel for the purpose of studying the mechanisms of spoilage; the spoilage changes were followed by using chemical and bacteriological tests. Nickerson and coworkers *(7)* irradiated haddock fillets with cathode rays; the fillets exposed to doses of 0.6 and 0.7 megarad showed a marked reduction in the number of microorganisms and were considered acceptable after being stored at 36° to 40° F for as long as 6 weeks. Nickerson and coworkers *(8)* reported that the flavor of halibut was not adversely affected by high level irradiation and that fresh halibut was much less affected by irradiation treatment than was defrosted frozen halibut. Groninger and coworkers *(4)* reported that irradiated halibut did not show any color, texture, or large odor changes, although the irradiated fish were significantly different in flavor from the controls. They found, however, that irradiated salmon were significantly different from the controls in both flavor and color. These studies included only limited information on the storage characteristics of irradiated fishery products.

In view of this need for information, the U. S. Bureau of Commercial Fisheries in cooperation with the Quartermaster Food and Container Institute for the Armed Forces began studies in 1957 on the use of ionizing radiation for the preservation of fishery products. These studies were designed to screen the available species and to select for possible initial commercial utilization those species of fish and shellfish that appeared to be most adaptable to the application of irradiation. The screening tests were conducted on both the Atlantic and Pacific Coasts at the Bureau's technological laboratories and at various universities through the use of research contracts. Presented here is the first of two reports on the work conducted at the Seattle Technological Laboratory.

The specific objective of this study was to determine the effect of varying doses of ionizing radiation on the palatability and storage characteristics of raw fillets of Pacific cod *(Gadus macrocephalus)* held at refrigeration temperatures above freezing.

EXPERIMENTAL PROCEDURE

Cod samples were first irradiated at various dosages up to a maximum of 1.86 megarads and then screened for organoleptic acceptability. Criteria for "acceptability" were determined by assuming that an irradiated fishery product would have to compete on the market with the same product preserved either by chilling or by freezing; therefore, any irradiation-induced changes would have to be relatively small. A product with moderate, but not objectionable, radiation odor or flavor was defined as "borderline."

The approximate storage life at temperatures of 32° to 35° F was determined on those irradiated cod samples rated organoleptically acceptable in the screening tests. During storage tests, the samples had to remain reasonably good in quality (marketable) in order to be judged acceptable.

Preparation and irradiation of samples. High-quality cod fillets were selected directly from a commercial filleting line. Fillets were packed in C-enameled cans, hermetically sealed without vacuum, placed in insulated shipping containers with wet ice, and shipped by air freight to the Materials Testing Reactor Gamma Irradiation Facilities at Idaho Falls, Idaho. Samples were irradiated at 0, 0.23, 0.46, 0.7, 0.93, 1.4, and 1.86 megarads for the screening test to determine their organoleptic acceptability and at 0, 0.1, 0.2, 0.23,* 0.46, and 0.7 megarad for storage tests. All samples were packed in wet ice and re-

* Two different lots of samples were irradiated; the difference in dosages of 0.2 and 0.23 was not intentional.

turned by air freight to our laboratory. In a typical shipment, fish were procured on Monday, packed, shipped, irradiated, and returned to our laboratory by Friday morning.

Reference samples and storage samples. Some of both unirradiated control samples and irradiated samples were frozen and stored at −20° F for use as reference samples during the storage tests. The other samples either were used immediately for the organoleptic screening tests or were placed at refrigeration temperatures above freezing for use as storage samples.

Quality evaluation. Quality changes induced by radiation treatment or that occurred during subsequent storage at refrigerated temperatures were determined by organoleptic, chemical, and bacteriological tests.

For the organoleptic evaluation, 5 to 6 tasters experienced in judging fishery products were used for the screening tests and 2 to 3 trained judges for the storage tests. For purposes of taste testing, fish samples were salted lightly and baked at 350° F for 15 to 20 min. Judges were asked to rate the various samples for odor and appearance on both raw and cooked samples and for flavor and texture on the cooked samples. The following scoring method was used:

5. Good: normal or original quality with absence of quality defects.
4. Reasonably good: trace or only slight presence of quality defects—not objectionable.
3. Fair: moderate presence of quality defects.
2. Poor: unacceptable; on borderline of edibility.
1. Very poor: inedible.

The judges were also asked to write comments on the quality defects observed.

In initial screening tests, irradiated samples were compared with unirradiated control samples. During storage tests, test samples were also compared with the frozen reference samples to determine the magnitude of quality changes caused by storage.

Chemical tests included determinations for total volatile base *(9)*, total volatile acid *(1)*, and trimethylamine *(2)*. In making standard plate counts, duplicate plate cultures were made using tryptone-glucose-yeast extract agar. Counts were made after incubating the cultures at 30° C for 5 days *(5)*.

RESULTS AND DISCUSSION

Screening test. The taste panel could not consistently distinguish between the 0.23-, 0.46-, and 0.7-megarad samples. In general, these samples had a slight radiation (burnt or scorched odor and flavor, which varied in intensity as much within samples of any one dosage level as between samples of different dosage levels. The 0.93-megarad samples had a slight radiation odor and a slight-to-moderate radiation flavor and were judged to be on the borderline of acceptability. The 1.4- and 1.86-megarad samples had moderately strong radiation odors and flavors and were judged unacceptable.

On the basis of these results, 0.7 megarad was selected as the maximum dose for irradiating cod fillets for the storage-life studies.

Storage-life tests. Results of the quality evaluation of the stored cod fillet samples are presented in Table 1. The control samples (no irradiation) had a storage life of 1 to 2 weeks. All of the irradiated samples were of good acceptable quality for more than 3 but less than 6 weeks but were on the borderline of acceptability for as long as 9 or 12 weeks. More frequent examinations between 3 and 6 weeks of storage will be required in future studies in order to determine the storage life more specifically.

Results of the chemical and bacteriological tests for quality are presented in Table 2. Since irradiation produces a marked reduction in the number of microorganisms *(5, 6, 7)* and alters the surviving microflora population on cod fillets *(5)*, the spoilage pattern apparently is changed. The chemical freshness tests, therefore, did not correlate well with the organoleptic evaluation and did not appear to be a reliable index of quality. For samples irradiated at

TABLE 1

Organoleptic quality evaluation of irradiated cod fillets after various storage intervals at 32° to 35° F.

Irradiation dosage	Organoleptic ratings after various storage intervals					
	4 days	3 weeks	6 weeks	9 weeks	12 weeks	15 weeks
Megarads						
0.1	Reasonably good: appearance and texture normal; very slight radiation odor and flavor	Reasonably good: no change except slight darkening of light meat	Fair—borderline of acceptability: darkening of white meat; slight sour odor; tasteless; rubbery or chewy	Very poor—inedible: sweet-sour odors; off flavors		
0.2	Reasonably good: appearance and texture normal; slight radiation odor and flavor	Reasonably good: slight radiation flavor; chalky and "condensed milk" flavor	Fair—borderline of acceptability: overall darkening of white meat; slight sour odor; rubbery or chewy	Fair to poor—unacceptable: defects noted at 6 weeks more pronounced	Very poor: strong off-odors on surface; off-flavors; inedible	
0.23	Reasonably good: appearance and texture normal; slight radiation odor and flavor	Reasonably good: no significant change	Fair—borderline of acceptability: lacking in fresh fish flavor; slightly firm; slight darkening	Fair—borderline of acceptability: no significant change	(No samples left)	
0.46	Reasonably good: appearance and texture normal; slight radiation odor and flavor	Reasonably good: no significant change	Fair—borderline of acceptability: lacking fresh fish flavor; slightly firm; slight darkening	Fair—borderline of acceptability: no significant change	Fair to poor—unacceptable: moderately tough	Poor: considerable darkening of white meat; tough; no spoilage odors
0.70	Fair: appearance and texture normal; radiation odor and flavor definite but not objectionable	Fair: no change	Fair—borderline of acceptability: lacking fresh fish flavor; slightly firm; slight darkening	Fair—borderline of acceptability: no significant change	Fair—borderline of acceptability: slightly tough	Fair to poor—unacceptable: slightly tough; darkening of white meat; no spoilage odors

the same dose level, however, values for the chemical tests and plate counts generally increased with the time of storage.

Total plate counts, including those determined on other samples but not reported here, were too inconsistent to be used as a reliable index of quality. MacLean and Welander *(5)* also have reported large differences in counts between replicate samples of irradiated cod fillets during storage at 32° F and have indicated that the variable bacterial contamination from commercial filleting may be the cause.

Dyer and Dyer *(3)* suggested a level of 10 to 15 mg of trimethylamine nitrogen (TMA N) per 100 g of cod fillet tissue as indicating that the fillets are on the borderline between acceptance and rejection. The unirradiated control samples after 2 weeks of storage at 32° to 35° F contained 11.4 mg of TMA N per 100 g of flesh, were organoleptically unacceptable, and had a high plate count. In comparison, the maximum TMA N value obtained during the 12-week storage period was 4.4 mg for the 0.1-megarad samples and 0.8 mg for the 0.2-megarad samples even though even-

TABLE 2

Quality evaluation by chemical and organoleptic tests on irradiated cod fillets after various storage intervals at 32° to 35° F

Dosage	Storage interval at 32° to 35° F	Organoleptic rating[2]	Total volatile base	Total volatile acid number	Trimethyl-amine	Total plate counts
Megarads	*Weeks*		*Mg N/100 g*		*Mg N/100 g*	*Bacteria/gram*
	0.5[1]	Good	7.2	8.8	0.14	0.5×10^6
	1	Reasonably good	46.8	66.5	6.4	0.5×10^6 1.3×10^6
0 (Control)	2	Very poor	64.0	110.0	11.4	5.0×10^6 59.0×10^6
	2.5	Very poor	69.9	145.6	16.6	5.4×10^6 13.0×10^6
	0.5[1]	Reasonably good	6.6	6.2	0.16	42,000
	3	Reasonably good	33.8	47.1	4.4	5.3×10^6 27.0×10^6
0.1	6	Fair—borderline	22.5	34.4	1.2	0.7×10^6 400.0×10^6
	9	Very poor	23.9	74.6	1.4	400.0×10^6
	12	Very poor	68.2	174.0	2.1	T.N.C.
	0.5[1]	Reasonably good	9.3	6.4	0.21	950
	3	Reasonably good	15.9	11.6	0.26	800 140,000
0.2 (lot 2)	6	Fair—borderline	31.8	13.8	0.48	30,000 260,000
	9	Fair to poor	21.4	14.4	0.80	0.8×10^6 1.3×10^6
	12	Very poor	24.7	24.4	0.80	13.0×10^6 62.0×10^6
	0.5[1]	Reasonably good	8.4	8.4	.....	100 150
	3	Reasonably good	8.8	10.9	.....	80,000 83,000
0.23 (lot 1)	6	Fair—borderline	21.8	29.2	.....	.....
	9	Fair—borderline	42.2	87.5	.....	380.0×10^6 410.0×10^6
	0.5[1]	Reasonably good	.....	.....	.....	20
0.46	9	Fair—borderline	16.2	11.4	.....	1.0×10^6 1.4×10^6
	15	Poor	20.8	14.7	.....	1,000 1,000
	0.5[1]	Fair	10.5	8.0	.....	10
	3	Fair	15.8	9.9	.....	30 2,500
0.70	6	Fair—borderline	18.8	31.2	.....	90 2,000
	9	Fair—borderline	28.9	45.0	.....	1,000 140.0×10^6
	15	Fair to poor	7.1	9.4	.....	1,000 30.0×10^6

[1] Samples were iced for 4 days during shipment to and from MTR, Idaho Falls, Idaho, for irradiation of samples.
[2] Condensed from data presented in Table 1.

tually the samples were considered organoleptically unacceptable and the total plate counts were high. These results indicate that irradiation may greatly affect the population of the TMA-producing microorganisms.

Maximum values for total volatile base and total volatile acid of the 0.1-megarad samples compared favorably with those of the unirradiated samples; however, values of the samples irradiated at higher dosage levels were inconsistent and considerably lower than were those of the samples that had not been irradiated. This result may be attributed also to the qualitative difference in the microorganisms surviving irradiation and to the fact that the samples were judged unacceptable from quality degradation resulting from loss of natural flavor, darkening of the white meat, and undesirable texture changes rather than because of the usual bacterial spoilage. Although at the lowest levels of irradiation used surviving microorganisms increased to a high count during refrigerated storage and may have contributed to the loss of quality, similar undesirable changes also occurred in samples that were irradiated at higher levels and for which the bacterial counts were low. These changes, therefore, appeared to result more from enzymatic and other chemical reaction than from bacterial spoilage. Even after 1 year of storage at 35° F, the 0.46- and 0.7-megarad samples did not develop the usual odors of bacterial spoilage, although they were discolored and extremely rubbery and tough in texture.

SUMMARY

Pacific cod fillets were irradiated at various dosage levels from 0 to 1.86 megarads to determine their initial acceptability and storage characteristics at refrigerated temperatures (32° to 35° F). The optimum irradiation dose for cod fillets appeared to be 0.46 megarad or lower. Irradiation at these low dosage levels increased the storage life of cod fillets at 32° to 35° F by about three times. The objective freshness tests investigated, including determinations for total volatile base, total volatile acid, trimethylamine, and plate counts, did not appear to be a reliable index of quality.

Acknowledgments

The author thanks Mr. John Spinelli for obtaining the fish and for preparing the samples and gratefully acknowledges the cooperation of the Quartermaster Food and Container Institute for the Armed Forces for irradiation of samples and the cooperation of the Food, Chemical, and Research Laboratories, Inc., Seattle, for the chemical and bacteriological determinations.

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The Variable Taste Perception of Sodium Benzoate[a, b, c]

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TASTE BLINDNESS to phenylthiocarbamide (PTC) *(2)*, which refers to the fact that PTC, while intensely bitter to most people, is practically tasteless to others, was discovered by A. L. Fox, a chemist, about 30 years ago. The validity of this phenomenon has been well established *(1)*. In 1954 Fox reported having found an analogous effect with sodium benzoate *(3)*. He claimed that there are marked individual differences in the qualitative taste response to sodium benzoate and that people can be reliably classified into "sweet," "salty," "bitter," "sour," or "tasteless" groups. He reported further that, when his test population was cross-tabulated on the basis of responses to both sodium benzoate and PTC, he found a definite relationship to food preferences. He suggested that this joint classification could be used for selecting flavor testing panels, so that their preferences would closely approximate those of a known population.

Verification of Fox's theory would have a significance even beyond the practical implications for panel selection. Tracking down the physiological basis for such consistent differences between people in taste perception would contribute important basic information toward developing a theory of the taste sense. All reports agree that individuals vary considerably in their taste responses to sodium benzoate, and similar effects have been reported for various other chemicals *(5)*. Usually the investigators have assumed, just as Fox did, that differences were physiologically determined.

Fox's paper stimulated a good deal of interest among food technologists, who are constantly seeking short-cut methods, and brief reports of his findings appeared in various technical publications and trade journals. However, in spite of the wide interest, but little further work has been done, either to verify his findings or to apply them. Hoover *(4)* did attempt to recheck Fox's work. He found that responses were extremely variable and concluded that the classification scheme was invalid. Exploratory experiments run at this Institute and at other laboratories, using water solutions of sodium benzoate as the stimuli, also gave results that were not consistent with Fox's theory.

So far the nature of the sodium benzoate effect has only been roughly indicated. Fox assumed that the variability is based on genetic differences, and this cannot be completely rejected; however, his experiment neglected certain important facets of the problem. Fox and others have used filter paper, impregnated with solution then dried, as the taste stimulus. The filter paper itself is not entirely flavorless and, even if it were, it might mechanically interfere with taste perception. Further, we must suppose that the effective strength of the stimulus could vary with the amount and pH of the subject's saliva. Further, even though the data were adequate, the interpretation might be faulty. The sensory experience aroused by sodium benzoate may be common among all persons, yet responses may be variable because the taste is unfamiliar and ambiguous so that the response is mediated in large part in the central nervous system, where it is influenced to a large extent by attitudes and expectations.

Problem. Exploratory experiments were required to narrow the range of possible explanations by describing the phenomenon more accurately. The present investigation was directed toward this end, being concerned, first, with the basic question of whether the response is variable and, secondly, whether variability, if found, is primarily a function of differences among people or differences in stimulus strength. The following hypotheses were set up:

(a) The qualitative gustatory response to sodium benzoate is no more variable than are responses to many common substances.

(b) The qualitative response to sodium benzoate varies among individuals in such a way that they can be reliably classified into a limited number of qualitative groups.

(c) The qualitative response to sodium benzoate varies as a function of stimulus strength.

METHOD

Test subjects. Test subjects were employees of this Institute—both men and women—most of whom had had previous experience in sensory testing, including psychophysical experiments which required judgment of fine differences. For several months prior to the experiment they participated in various exploratory studies on sodium benzoate, including threshold determinations, and were familiar with its taste.

Test materials. The stimuli were solutions of C. P. sodium benzoate made with distilled water which had been filtered through activated charcoal. Thresholds, established by the method of constant stimulus differences, were found to be quite different among the test subjects, ranging from .008% to .400%. A series of concentrations was finally selected to cover

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[a] This paper reports research done in partial fulfillment of the requirements for the Ph.D. degree at the Illinois Institute of Technology under the direction of Dr. P. S. Shurrager, Chairman, Psychology Department. His advice and assistance are gratefully acknowledged.

[b] This paper reports research undertaken at the Quartermaster Food & Container Institute for the Armed Forces, and has been assigned number 1008 in the series of papers approved for publication. The views or conclusions contained in this report are those of the author. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

[c] Presented at the 19th Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 19, 1959.

the range from near the threshold for the most sensitive subjects to the point where the flavor was strong enough to be definitely unpleasant. The concentrations were spaced in the log series: .01%, .03%, .10%, .31%, and 1.00%.

Test method and procedure. The Flavor Analysis questionnaire (Figure 1) was used to rate each sample for intensity of

FLAVOR ANALYSIS

Name_____ Date_____

INTENSITY

Sample Code_____

	none	slight	moderate	strong	extreme
Sour	|	|	|	|	|
Salt	|	|	|	|	|
Sweet	|	|	|	|	|
Bitter	|	|	|	|	|

Figure 1. Questionnaire for flavor analysis tests.

each of the 4 qualities: salt, sweet, sour, and bitter. The instructions given to the subjects describe the detail of the test: "Your task will be to analyze the flavor of each sample. You will do this by indicating the strength of each of the qualities, —*salt, sour, sweet,* and *bitter,* on the questionnaire forms provided. Use a different form for each sample. Please consider and rate the qualities in the order in which they appear on the questionnaire. You will have all the time you need to consider each sample and you may taste it as often as you wish. Ask for more of a solution if necessary. Return the glass as soon as you finish a sample and rinse your mouth thoroughly with water. There will be a one-minute wait from the time you return one glass until you receive the next sample. There will be 5 samples in all.

These are water solutions of sodium benzoate. This material is not harmful; however, you are asked to spit out the solution rather than swallow it in order to reduce carry-over effects from one sample to the next."

The same questionnaire was used to estimate total flavor intensity by asking for a single rating of over-all intensity without attempting to break it down into the separate qualities.

Experimental design. A subject judged all 5 solutions at each session. The 120 possible different orders of presentation were assigned randomly to test subjects to balance order effects insofar as possible. The 24 possible orders of appearance of the 4 qualities on the questionnaire were also balanced and were used as nearly as possible with equal frequency. Sessions were conducted at about weekly intervals. There were 2 replications of the experiment. The first involved a total of 5 sessions. The second replication was run 9 months after the completion of the first and involved only 2 sessions for each subject. Of the 25 subjects who participated in the first series of tests, only 18 were available for the second. Rating of over-all flavor intensity was done by the 25-member panel soon after the first replication of the flavor analysis.

Data analysis. The data were subjected to several analyses of variance. The analysis reported here involved only mean rating, i.e., the average, for each subject, of the ratings given to each sample for each quality. Data were used only from the 18 subjects who participated in both replications. The error terms for determining reproducibility of results were as follows: each main effect was tested against the pooled variance from all interactions involving replication and the particular effect; replication main effect itself was tested against the pooled variance from "subject" and the subject-replication interaction; and interactions were tested against the pooled variance from all higher order interactions involving the same factors.

In analysis of the main experiment the factor of concentration was given special treatment, being broken down into four independent comparisons. The reason for this approach, and the comparisons themselves, are discussed below.

RESULTS AND DISCUSSION

Figure 2 plots the relation of over-all flavor intensity for the 5 samples against concentration. Two points may be noted. First, the two weakest concentrations rated the same, and second, beyond this point the function is linear.

In Figure 3 the average intensity ratings from the flavor analysis experiment have been plotted against concentration separately for each of the four qualities.

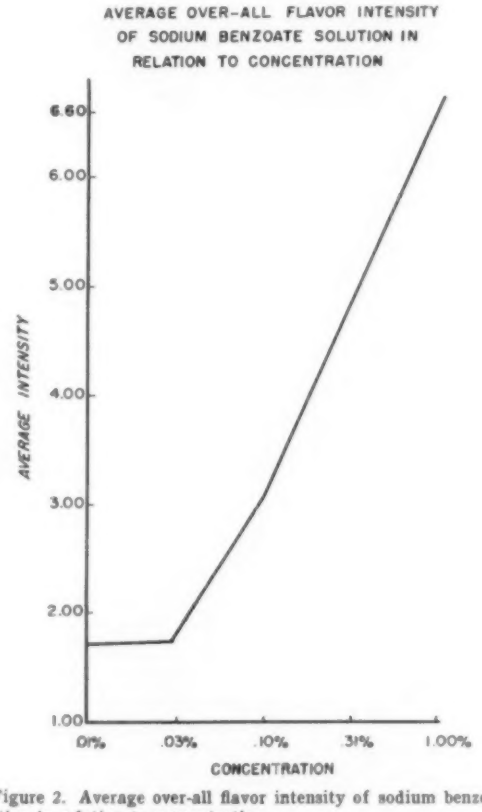

Figure 2. Average over-all flavor intensity of sodium benzoate solution in relation to concentration.

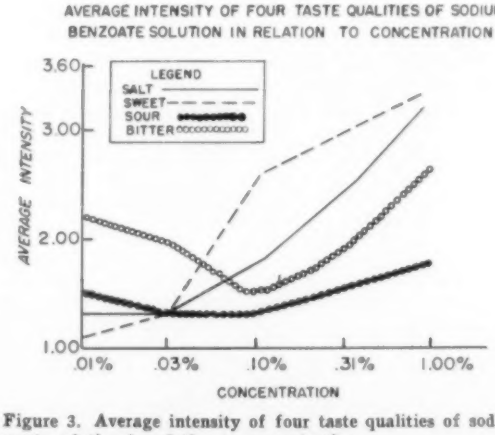

Figure 3. Average intensity of four taste qualities of sodium benzoate solution in relation to concentration.

These plots are based on the average ratings over both replications of only those 18 subjects who participated in both. Results are not shown separately for the replications because the 2 charts were closely similar. At the two low concentrations, the average ratings were practically identical; however, for the higher concentrations, the *salt*, *sweet* and *sour* averages were somewhat higher in the first replication. This is reflected in the significant interaction between replication and concentration—Comparison B.

Although these plots start at about the same level as that for over-all intensity, they do not rise to the same level at the highest concentrations. Of course, in the flavor analysis the subjects had a quite different and more difficult task than in rating over-all intensity. Note that the curve for bitter differs from the others. It starts at a definitely higher level and has its minimum at the middle concentration before again ascending. The higher level of bitter at the lowest concentrations appears to be unrelated to sodium benzoate, since many of the subjects judged the distilled water itself to be bitter.

The general level of intensity, considering all qualities, is the same for the two weakest solutions, which agrees with the results on over-all intensity. This confirmed that we had, in effect, included two "base line" or "zero" samples in the experiment. Since this would tend to cause spuriously high interactions of concentration with quality, a method of handling concentration was adopted which avoided this. Concentration was broken down into the following orthogonal comparisons:

Comparison A—difference between the two weakest concentrations.

Comparison B—the two weakest *vs* the three strongest concentrations.

Comparison C—linear effect among the three strongest concentrations.

Comparison D—quadratic effect among the three strongest concentrations.

Table 1 extracts from the analysis of variance those figures which are important to the present discussion. The higher order interactions, most of which were insignificant or borderline, are not shown separately.

The main effect of replication is not significant, which indicates that the average level of rating was the same both times. This speaks favorably for reliability; however, the interactions of replication with subject, quality, and concentration Comparison B—were all significant at about the 1% level, which shows that there was some shifting between replications. The rank order of the subjects' average ratings changed to some extent between replications; also the differences between averages for the different qualities were not the same, although they fell in the same rank order in the 2 replications.

The significant main effect of subject was expected and reflects only people's differing levels of sensitivity and different habits of using the scale. The significant main effect of quality verifies what is obvious from Figure 3, namely, that the over-all level for some qualities is higher than for others. The various concentration main effects may be interpreted as follows: Comparison A is not significant, which verifies that the 2 weakest samples were essentially the same. The insignificant Comparison D effect shows the absence of quadratic effect among the top 3 samples. However, both Comparison B and Comparison C account for a high proportion of the total variance. Again, this was expected and simply shows that higher concentrations are rated as more intense.

TABLE 1

Analysis of variance for flavor analysis of sodium benzoate

Source of variance	Degrees of freedom	Mean square	Significance
Replication	1	12.30	....
Subject	17	10.00	<0.1%
Quality	3	18.65	<0.1%
Concentration Comparison A	1	.39	....
Concentration Comparison B	1	92.23	<0.1%
Concentration Comparison C	1	69.52	<0.1%
Concentration Comparison D	1	.56	....
Subject-quality	51	3.20	<0.1%
Concen. Comp. A—Quality	3	.76	1.0%
Concen. Comp. B—Quality	3	19.61	<0.1%
Concen. Comp. C—Quality	3	2.55	<0.1%
Concen. Comp. D—Quality	3	1.35	....
Interactions (2-factor) with replication:			
Repl.—Subject	17	1.53	1.0%
Repl.—Quality	3	2.58	1.0%
Repl.—Conc. compar. A	1	.10	....
Repl.—Conc. compar. B	1	9.00	0.5%
Repl.—Conc. compar. C	1	1.76	....
Repl.—Conc. compar. D	1	.26	....
Other 2-factor interactions with subject:			
Subject—Conc. compar. A	17	.32	5%
Subject—Conc. compar. B	17	1.95	....
Subject—Conc. compar. C	17	1.83	....
Subject—Conc. compar. D	17	.17	....
All 3-factor and 4-factor interactions combined	539	.87	

It is the two-factor interactions which are most important for this experiment. A significant subject-quality interaction would indicate that responses differ among people, and would tend to support Fox's original claim. A significant concentration-quality interaction, on the other hand, would indicate that the variable responses are a function of differences in strength of the stimulus. The analysis gives both hypotheses some support. Subject-quality interaction is significant at beyond the 0.1% level, as are also the interaction of quality with concentration Comparisons B and C. The mean square for the Comparison B-quality interaction is much higher than for either of the others but this is partly spurious. It shows that the relative order of the 4 qualities based on the average of the 3 strongest samples was different from the relative order based on the average of the 2 weakest, but we have already noted that the latter were so weak that the order of the qualities was probably due to chance. The 1% level of significance for the concentration Comparison A-quality interaction was probably due to the previously mentioned bitter responses to the distilled water and thus would have no bearing on the sodium benzoate problem. The interaction of quality with concentration Comparison C, however, reflects significant differences in the quali-

ties reported at different above-threshold concentrations, hence bears directly on hypothesis (c).

An important finding that emerged, not from formal analysis of the data, but from inspection of the patterns of responses for individual subjects was that almost all of them reported more than one quality. Some subjects consistently rated a given quality highest yet ascribed intensities to one or two others that were far above the negligible level; others would rate 2 or 3 qualities at about the same level, or their relative ratings of the qualities would be different for strong and weak concentrations. No reasonable scheme of classifying subjects according to their patterns of response could be devised, since there would have been nearly as many classes as subjects. One finding, however, is definite—sodium benzoate flavor is a mixture, or blend. Thus, any experimental technique which required report of a single quality would misrepresent the facts by forcibly discarding information.

Finally, we come to a question of general control. The results show that there is considerable variability in the taste response to sodium benzoate, but is this unusual? Perhaps such variability is characteristic of the taste response in general and not just of sodium benzoate. As a check on this possibility, comparable flavor analysis tests were run on caffein, sucrose, sodium chloride, and citric acid. The subjects were 19 of the original panel. The stimuli were log series of 4 concentrations of each substance, the weakest being set at a level just above the estimated group threshold. All 16 samples were included in the same experiment. The order of presentation was determined randomly for each subject and four sessions were required to test the complete set.

Results are shown in Figure 4, separately for each substance. The average ratings are plotted against concentration separately for each quality. Although some confusion is demonstrated at the lower levels, as concentration increases the single quality appropriate to the substance emerges and the others drop off to the "noise" level. Definitely there is much less variability than for sodium benzoate.

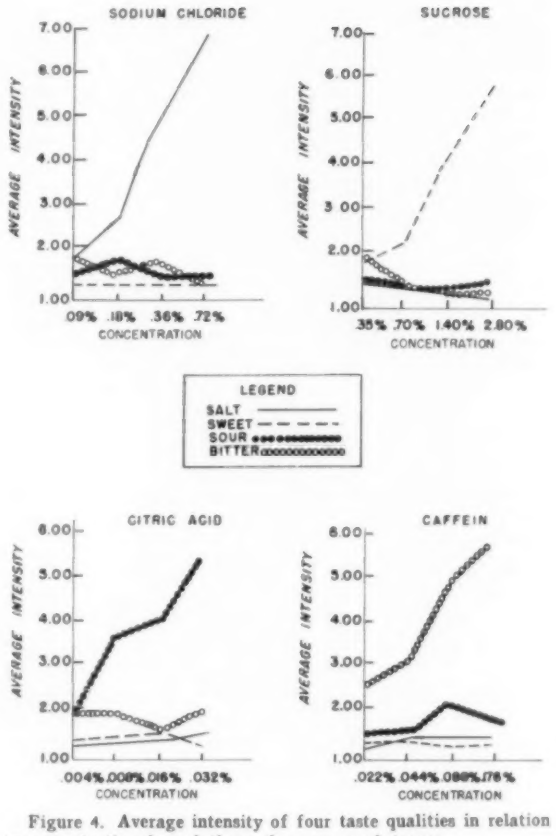

Figure 4. Average intensity of four taste qualities in relation to concentration for solutions of common substances.

CONCLUSIONS

Let us assess the results in terms of the hypotheses set forth in the introduction: The first hypothesis, that the response to sodium benzoate is no more variable than for many common substances, can be rejected on the basis of comparison with the flavor analyses of common substances. The second hypothesis can also be rejected, but only because it overstates the case. We have confirmed that responses vary among individuals, but our data strongly suggest that such responses would not be a reliable way of classifying people. The simple statement of the third hypothesis is confirmed in that responses were shown to vary as a function of stimulus concentration, among other things.

The results of this study are not definitive in the sense that they completely "explain" variation in the taste response to sodium benzoate. The variation has been confirmed and we have briefly explored some of the characteristics of the phenomenon. Definitely, it would appear that any simple model will not serve. Fox implied that the differences in perception were due to basic physiological differences. This may be partially true; however, once it is seen that we are dealing, not with a simple 5-category classification, but with a complex set of patterns, it is reasonable to look for multiple causes. Some of these may be physiological, but it is also likely that much of the variation is related to differences among people in learning and verbal habits, specifically the language they use to describe their taste experiences.

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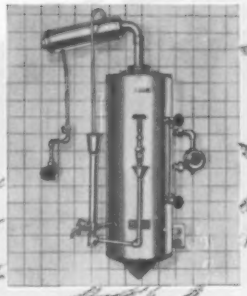

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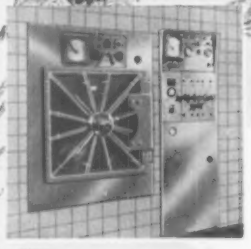

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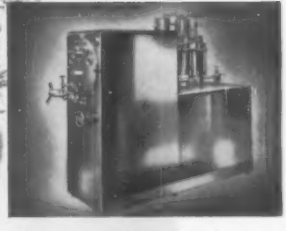

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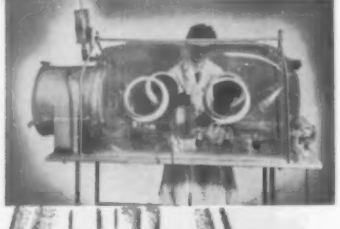

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A Continuous Process for Dehydrating Honey

(Manuscript received April 6, 1960)

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Philadelphia 18, Pennsylvania

THE DEVELOPMENT of a dried honey having good color, flavor, physical form and keeping properties, and which could be produced and sold at reasonable cost, should enhance the acceptance and use of this agricultural commodity, especially by the baking industry.

The honeybee is in large part responsible for the pollinating of some sixty important commercial fruit and vegetable crops. The value of the bee's pollination services is estimated to be several times the value of the honey and beeswax it produces; yet in many cases the beekeeper receives little or nothing in return for this service. Rising costs of operation without a corresponding increase in income have caused many beekeepers to leave the business. Increased demand for honey could halt or reverse this trend, and thus benefit agriculture in general by retaining the valuable pollinating services of the honeybee.

This paper describes a continuous process which has been developed on a pilot-plant scale for the production of dried honey having excellent color and flavor and having free-flowing granular physical form. The potential commercial uses for this product, if realized, could lead to a significant increase in honey consumption.

THE PROCESS

The continuous process developed for producing dried honey is an extension of the process previously developed and described by the authors for the continuous dehydration of fruit juices *(4)*. The liquid honey, either pure or containing added sucrose syrup, is rapidly dehydrated under vacuum in a mechanically agitated thin-film evaporator to yield a molten product practically free of water. The molten product is fed to a pair of chilled metal rollers which squeeze it into a thin sheet, cool the sheet to room temperature, and break it into small brittle pieces. The pieces are comminuted to the desired size and packed in sealed containers together with a desiccant to further reduce moisture.

APPARATUS AND OPERATION

A number of equipment manufacturers offer evaporators of the mechanically agitated thin-film type. The one used by the authors was a Laboratory Model Turba-Film Evaporator made by Rodney Hunt Machine Co.[b] It has approximately one square foot of heat transfer surface and is rated to evaporate 40 pounds per hour of water at 27-inch vacuum using steam at 275° F. In this machine the feed flows by gravity down the inner wall of a hollow vertical cylinder which is evacuated and is heated by a steam jacket. Centrally located within this cylinder is a rotating agitator shaft having three straight vertical fins or blades which run the length of the cylinder wall and extend to about 0.030 inch from it. These rotating blades keep the feed in highly turbulent motion along the cylinder wall, thereby preventing local overheating while promoting rapid, efficient heat transfer. The discharge opening at the bottom of the evaporator was enlarged by the authors to facilitate flow of the highly viscous molten product at this point. Figure 1 gives a general view of the evaporator and the auxiliary equipment.

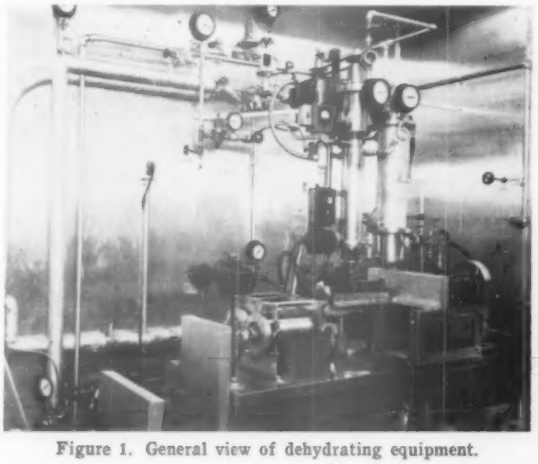

Figure 1. General view of dehydrating equipment.

The drying, size reduction and packaging operations are carried out within a room in which the relative humidity is maintained at about 10%. This is necessary to prevent the hygroscopic dried honey from picking up atmospheric moisture and becoming caked.

Total cost of the evaporator and auxiliary equipment, plus the low humidity room and its dehumidifying equipment, is approximately $17,000 at today's prices.

The drying process is depicted in the flowsheet, Figure 2. Honey to be dried is warmed to 90–95° F to reduce its viscosity and then placed in the feed tank (1). About 30 ppm of a food grade silicone-base antifoaming agent[c] is added to the honey and thoroughly dispersed with an air-driven agitator, which is then left turning slowly. The feed rate is set at between 30–35 pounds per hour (solids basis) by adjusting the rpm of the gear-type positive delivery feed pump (2). Steam pressure on the jacketed-tube type feed preheater (3) is adjusted so that the honey will be a few degrees above its boiling point when it enters the evacuated evaporator. Vacuum steam at 160–175° F is used in the preheater jacket to prevent overheating. A back-pressure valve (4) at the end of the feed line maintains pressure greater than atmospheric within this line to help insure uniform feed flow. If the feed line and feed pump were to be subjected to the evaporator vacuum, the pump delivery rate would become erratic and the preheated feed would flash, causing it to enter the evaporator in uneven "slugs," hindering operation.

The honey passes through the heated zone of the evaporator in about half a minute, during which its water content is reduced to about 1%.

At the bottom of the evaporator the dehydrated honey, which has a high viscosity but flows at the existing temperature

[a] Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

[b] Reference to certain products or companies does not imply an endorsement by the Department over others not mentioned.

[c] Individual manufacturers should consult the Food and Drug Administration, Washington 25, D. C., and the Food and Drug officials of the individual states involved, to determine if the use of any proposed additive is permissible, and if so, what limitations are placed on its use.

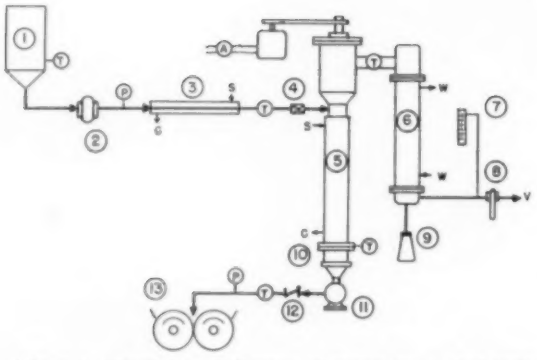

Figure 2. Flowsheet and diagram of apparatus. 1, feed tank; 2, feed pump; 3, feed preheater; 4, back pressure valve; 5, evaporator; 6, condenser; 7, absolute pressure manometer; 8, vacuum regulator; 9, condensate receiver; 10, sightglass; 11, product pump; 12, check valve; 13, chilling rolls. T, thermometer or thermocouple; S, steam; C, condensate; W, water; V, vacuum source; A, ammeter; P, pressure gage.

(230–240° F), falls through a sight glass (10) and into the product pump (11). The pump discharges the product through a check valve (12) and into the product line which ends in a reinforced flexible tube. The tip of this tube is mounted on a reciprocating carriage that distributes the hot product along the nip of the two cooling rolls (13). These rolls of chrome-plated bronze are hollow and have water at 35° F circulated through them. They squeeze the hot product into a sheet about 0.015 inch thick and cool it to room temperature, at which temperature it is a glassy solid. The brittle sheet is scraped off the rolls by doctor knives and breaks into pieces about an inch on a side. These "flakes" can readily be broken to smaller particles by forcing against a screen with a rubbing contact, or by using a small hammermill. Sizes down to through 20-mesh, about the size of ordinary granulated sugar, have been prepared.

In Table 1 are shown typical values of the important operating variables of the continuous evaporator, for the three different feed compositions studied.

TABLE 1

Typical operating conditions of mechanically-agitated thin-film evaporator when dehydrating honey

Operating variable	Feed composition (solids basis)		
	Pure honey	⅔ Honey ⅓ Sucrose	½ Honey ½ Sucrose
° Brix (% solids) in feed	83	78.5	78.6
Feed rate, lb solids per hour	30	30	30
Feed temp at evap'r inlet, ° F	128	128	130
Abs pres in evap'r, inches Hg	1.16	2.00	2.85
Boiling point of water, ° F, corresponding to abs pres	84	101	113
Steam on evap'r jacket, psig	9.8	13.1	10.3
Steam on evap'r jacket, ° F	239	246	240
Product temp leaving evap'r, ° F	238	241	234
Boiling point rise in product, ° F	154	140	121
Moisture content of product, %	0.80	0.97	1.00
Rotor rpm	1060	1100	1060

To provide added protection against caking during storage, an envelope containing desiccant is packaged with the product. This envelope is made of a tough creped kraft paper which is vapor-permeable but dust-tight. It contains granulated calcium oxide in amount equal to about 5% of the weight of the dried honey. The desiccant maintains a very dry atmosphere within the container and over an extended time gradually lowers the moisture content of the product. As discussed under STORAGE TESTS below, the presence of the desiccant raises appreciably the temperature which the material can withstand without caking. Thus its use, while not mandatory, is desirable.

FEED MATERIAL

Several different types of honey were dried, including bakers' amber, white alfalfa-sweet clover, and fancy clover (table-grade white). These were dried in the pure state and also with added sucrose. Added sucrose was found to give a more brittle product possessing greater resistance to caking. Sucrose was added before drying in the form of a syrup of about 70° Brix. All of the honeys dried, pure and with added sucrose, handled satisfactorily in the equipment.

ORGANOLEPTIC EVALUATION OF PRODUCT

The dried honey from several of the runs was reconstituted with water back to its original solids content, and taste tested against the original liquid honey by a panel of thirteen to eighteen tasters. The reconstituted product was found to be very similar in flavor to the original honey, and was rated only slightly below the original in acceptability. Aroma of the reconstituted honey was a little weaker than the original. With the table-grade dried honey, a few of the tasters detected a trace of heat-developed flavor which they considered as not objectionable.

Color of the honey did not change significantly on drying. The pure bakers' amber honey had Pfund color readings of 92 mm and 94 mm before and after drying, respectively. The pure, white alfalfa-sweet clover honey had readings of 24 and 32 mm Pfund, both of these readings being in the "white" class.

STORAGE TESTS

A number of tests were run to determine the stability of the dried products during storage. Flavor and color of the dried honeys showed no appreciable change after a year's storage at room temperature. Caking of the dried products, however, did occur under some conditions. The dried honey is a thermoplastic material, and if stored at sufficiently high temperature it will soften and may cake.

For the caking tests, samples were run at least in duplicate. Containers used included one- and two-quart Mason jars and No. 10 cans. In evaluating the samples after storage, caking was considered not significant if any lumps present could easily be broken apart by brief light shaking, or by applying a light direct pressure, or if they constituted only a very small percentage of the total sample.

When caking did occur under a given set of conditions, it usually took place within from one to ten days. Where significant caking did not occur, the sample was held under the test conditions for at least two months.

The results of the caking storage tests are summarized in Table 2. The temperatures shown are approximate, in that other variables besides those listed also affect caking. For example, the greater the depth of material in the container, the greater the tendency to cake. The depth of material used in these tests was about six inches. Depths appreciably greater

TABLE 2

Approximate temperature limits for storage of dried honeys without objectionable degree of caking[1]

Type of honey	Per cent added sucrose	Particle size	Approx temp limit for storage without objectionable caking, ° F	
			Without desiccant	With desiccant
Bakers' amber	0	2-mesh	75	85
	0	−4-mesh	75	85
	33	−4-mesh	85	95
	33	−20-mesh	....	93
	50	2-mesh	....	>100
	50	−20-mesh	....	>100
White, alfalfa-sweet clover	0	−4-mesh	....	85
	33	−4-mesh	85	95
	33	−20-mesh	....	93
Fancy clover, table-grade white	33	2-mesh	85	....

[1] Limits shown approximate only. Caking affected also by depth of material, time at temperature, mechanical agitation, dusting additives.

(say twice as much) would probably lower the temperature limits slightly.

Conversely, shaking or mechanical handling reduces the chances of caking. Caking takes time, sometimes weeks, and shaking by redistributing the particles breaks apart any incipient points of coherence that have already formed between adjacent particles. Thus it extends the time that the material remains free-flowing.

As shown by Table 2, the addition of sucrose has a marked effect in increasing the resistance to caking. The presence of inpackaged desiccant likewise raises appreciably the temperature which the material can withstand without caking. The effect of 1% of starch when added to the dried product as a dusting agent was to increase the resistance to caking only slightly. Other dusting agents, such as calcium stearate for example, might prove to be more effective although their use has not been studied.

If it were desired to eliminate the inpackaged desiccant, the product containing 50% sucrose and 50% honey solids would probably store satisfactorily without desiccant at temperatures up to 90–95° F.

HONEY ESSENCE

The water removed from the honey in the evaporator is condensed and collected. It has a fairly strong honey odor. This condensate was concentrated in aroma strength in a small glass continuous distillation column, with the overhead product constituting a honey "essence" of theoretical 100-fold strength. "Theoretical fold" is computed as the ratio of volume of original honey to volume of essence derived therefrom. To evaluate the aroma strength of this "100-fold" essence, a series of dilutions of it were prepared and compared against the original honey for aroma strength by a panel of 17 members. A fold of 70 was thereby determined for the essence. The character of aroma of this essence is practically identical with that of the original honey. It is believed that this essence could find use as a flavoring material.

Restoration of the 100-fold essence to the dried molten honey before feeding to the chilling rolls could have been done, as the authors did in preparing dried fruit juices *(4)*. However, the dried honey seemed to possess adequate aroma without restoring essence, so that this step was not considered necessary. Also, essence restoration would raise the product moisture content and lower it softening temperature somewhat, which is undesirable. Sale of this essence separately could add to the income realized from the process.

COST OF MAKING PRODUCT

A detailed calculation was made of the cost of producing the dried honey commercially. This calculation assumed the building of a completely new plant without any credit costwise for use of existing facilities. Scale of output was taken as 1,000,000 pounds of dried honey per year produced in 250 working days of 8 hours each. The fixed capital required was $150,000. When making pure dried honey (no added sucrose), the cost to make was computed at about 28 cents per pound of dried product. A breakdown of the items making up this cost is shown in Table 3. If the production rate were doubled by working 16 hours a day, the cost to make would be reduced to about 25 cents per pound of dried product. The selling price would, of course, be higher than the cost to make since it would include the additional items of the cost of selling and the profit.

Most likely a commercial plant for drying honey would be set up in conjunction with an existing plant already processing and packing liquid honey. In this case part of the equipment and facilities required for the drying would likely be available, such as a building, boilers, an office, etc. Using these facilities would reduce somewhat the cost to make as well as reducing the fixed capital required. When making dried honey containing added sucrose, the cost to make per pound of dried product would be less than the figures stated, since sucrose costs less than honey solids.

A commercial plant set up to manufacture the dried honey could also be used to produce a wide variety of dried fruit juices using the method described in a previous publication by the authors *(4)*. The equipment for drying the concentrated juices is practically identical to that used for drying honey, and the operating procedures are very similar.

USES OF THE PRODUCT

One of the potential uses for the dried honey is in commercial and retail baking. Although a considerable portion of the total honey crop is used by the baking trade, the actual amount consumed is quite small compared to the total quantity of sweeteners (chiefly sucrose) that are used in baked goods. One reason for this may be that the handling of liquid honey presents problems to the baker. It is commonly shipped and stored in 5-gallon (60 pound) cans. Frequently it granulates (crystallizes) within the can, necessitating special treatment and equipment to recover it. Since honey has a high viscosity, loss in adherence to the containers is appreciable unless special efforts to recover it completely are taken. The free-flowing dried honey would eliminate these problems of viscosity and granulation involved in handling liquid honey.

One "natural" application for the dried honey is in the field of packaged dry baking mixes for household use. Here the honey would add sales appeal, as well as conferring the advantages which have been shown to result from its use in various baked goods, including improvements in flavor, color, texture, aroma and keeping quality *(1, 2, 3)*.

Another potential market for the dried honey is in confectionery. Honey is now included in certain types of candy, such as honey nougats, sponges and caramels. Use of dried honey would eliminate the flavor-damaging high-temperature cooking now necessary to remove water in preparing many types of honey candies.

Samples of the dried honey have been distributed to many interested parties, including honey processors

TABLE 3

Individual items comprising cost to make of pure dried honey on a commercial scale

Item	Cost per pound of dried product, cents
Liquid honey (at 15¢/lb, 82% solids)	18.5
Direct labor	1.0
Indirect labor	1.9
Packaging (in 50-lb cans)	1.0
Fixed charges (insurance, taxes, depreciation, interest on fixed capital)	2.6
Employee non-wage costs	0.3
Utilities	0.3
Maintenance, supplies, miscellaneous	1.2
Interest on working capital	0.5
Administration and general expenses	0.4
Research and development	0.4
Total	28.1

and distributors, food processing companies, a state honey advisory board, and university research scientists. At least two processors have shown active interest in possibly producing and marketing the dried honey, and one of these is currently planning a small-scale market test.

SUMMARY

A continuous process has been developed on a pilot-plant scale for producing dried honey. The product has color and flavor quite close to that of the original honey; has free-flowing, granular physical form; and has long shelf life. It can be produced from both table and baking grades of honey, and either with or without the addition of sucrose before drying. The addition of sucrose raises the temperature at which the dried product will soften and thus makes it more resistant to caking at elevated temperatures. Honey essence of high potency and true aroma character can be obtained as a byproduct. Estimated costs of making the dried honey on a commercial scale are presented. The dried honey has applications in commercial baking, in confectionery making, and in the production of packaged dry baking mixes.

Acknowledgment

The authors wish to thank Dr. Jonathan W. White, Head, Honey Investigations at the Eastern Regional Research Laboratory, for his very helpful cooperation and counsel.

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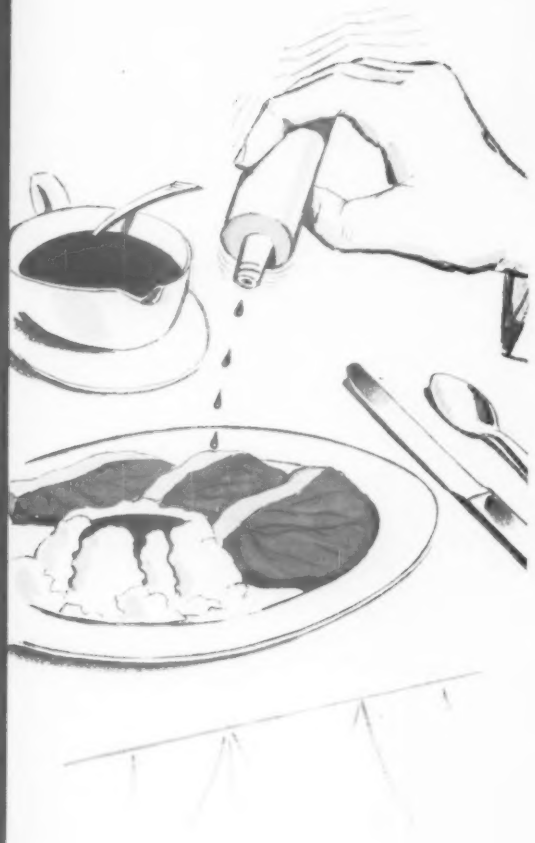

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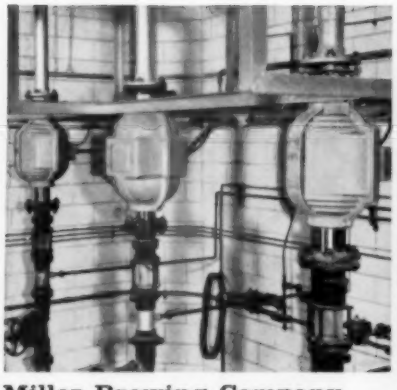

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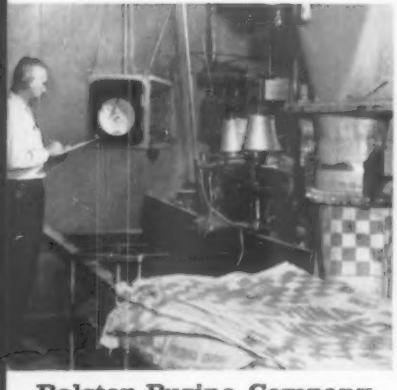

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Freezing, Defrosting and Frozen Preservation of Cake Doughnuts and Yeast-Raised Doughnuts[a]

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American Institute of Baking, Chicago, Illinois

(Manuscript received April 1, 1960)

MOST BAKERY FOODS are very perishable. When stored at room temperature they rapidly become stale which causes a considerable economic loss to the consumer as well as the baking industry. It has long been known that if bread is frozen quickly and stored frozen it remains fresh for an extended period *(5)*. Within the past few years results of extensive systematic studies to determine the effects of freezing and defrosting rates and temperature of frozen storage on bread freshness and firmness have been published by Pence and co-workers *(12, 13, 14)*. The same investigators have also studied the conditions required for the freezing of cakes *(10, 11)*.

Most of the published material on the freezing of doughnuts is fragmentary. Gordon *(6)* reported that unwrapped doughnuts could be stored successfully for 7 days at a freezer temperature of 8° to 10° F. He found that freezing at 0° F minimized condensation on the icing during freezing and that rapid defrosting had the same effect. Tyor *(17)* froze both cake doughnuts and yeast-raised doughnuts at −10° F with forced air circulation and stored them at 10° F. He recommended that icing be applied only after defrosting. Anderson *(1)* stored boxed cake doughnuts for 4 days at 8° F. He found them palatable but noticeably firm. A study of the effect of freezing packaged cake doughnuts on their firmness was reported by Steinberg *(16)*, who also investigated the stability of icings and glazes.

This paper reports an investigation undertaken to obtain information about consumer acceptance of frozen cake and yeast-raised doughnuts. Changes in acceptance caused by variation in conditions of freezing, defrosting, and storage were measured by sensory panel and firmness tests.

METHODS AND MATERIALS

Doughnuts were made in the Experimental Bakery, American Institute of Baking, using formulas shown in Table 1. Commercial formulas vary through a considerable range in ingredients and their proportions. The formulas used in these experiments represent medium-rich products with a high degree of acceptability when fresh. The frying temperature was 370° to 380° F. Cake doughnuts were made in 2 sizes, approximately 10 oz per doz and 13 oz per doz. Yeast-raised doughnuts weighed 20 oz per doz. None were iced or glazed. When packaged, commercial doughnut boxes supplied by large wholesale bakers were used. These were of 0.018 inch laminated paper board with grease-proof inner lining and cellophane window. Boxes were of 2 types. Yeast-raised doughnuts and the cake doughnuts weighing 13 oz per doz were packed in a single row to fill boxes measuring 2¾ by 2¾ by 9⅝ inches. Cake doughnuts weighing 10 oz per doz were packaged in 4 rows of 3 to fill boxes measuring 2½ by 4¼ by 8 in.

TABLE 1

Formulas for doughnuts

Ingredient	Cake doughnuts parts by weight	Yeast-raised doughnuts[1] parts by weight
Flour	100	100
Water	42	52
Yeast	.....	6
Salt	1.5	2.3
Sugar	37.5	16
Baking powder	3	.....
Nonfat dry milk	6.3	5
Shortening	6.3	16
Whole eggs, frozen	.....	16
Egg yolks, dried	7.8	.....

[1] Fermentation time 30 min at 76° F.

Doughnut temperatures were measured with 30-gage copper-constantan thermocouples inserted to the center midway between the outside and the hole. Readings were made with a Brown portable potentiometer. Measurements of packaged doughnuts were made on a doughnut in the center of the package. The equipment for freezing and defrosting has been described elsewhere in detail *(7)*. Freezer and defrosting cabinet were thermostatically regulated to maintain the preset temperature within ±2° F. Each was equipped with a variable speed blower. During freezing, temperature measurements were made at 1 to 2 min intervals for single unwrapped units and at 5 min intervals for packaged units from 70° F to a temperature 10° F above that of the freezer. During defrosting the measurements were made from 0° to 70° F.

For evaluating the effects of conditions of freezing, defrosting, and frozen storage, firmness measurements were made with the Baker compressimeter *(15)* using a compression of 2.5 mm. Tests were made on one-half inch cubes of crumb. Two cubes were taken from each of 10 doughnuts and the values averaged. Staling of bakery foods consists of all changes that occur during storage that result in decreased consumer acceptance except those due to the action of spoilage organisms *(4)*. In addition to firming there are changes in aroma, taste, texture, crumbliness, and perhaps other factors. Most of these cannot be measured objectively. They can best be determined under laboratory conditions by means of a sensory panel. Sensory panel tests were made by a panel of 20 members selected because of their ability to distinguish different degrees of freshness. The procedure for panel selection and for product testing was that employed by Bechtel and Meisner *(2)* except that a symmetrical 8-point rating scale was used. The ratings were *very fresh, fresh, moderately fresh, slightly fresh, slightly stale, stale,* and *very stale*. For tabulation and statistical analysis of the results the rating *very stale* was given the value 1. Successive ratings were given consecutive integers to 8 for *very fresh*. Throughout this paper the terms describing freshness and staleness refer to results of panel tests. All experiments were performed in duplicate.

[a] The research on which this paper is based was conducted by the American Institute of Baking under contract with the U. S. Department of Agriculture under the authority of the Research and Marketing Act of 1946. The contract is supervised by the Western Utilization Research and Development Divison of the Agricultural Research Service.

RESULTS AND DISCUSSION

Effect of temperature and air flow on rate of freezing. In Table 2 data are given for the times required to freeze unwrapped and packaged cake doughnuts from 70° F to 10°, 0°, and −10° F under various conditions of freezer temperature and air flow rate. Similar data are given for yeast-raised doughnuts (Table 3). No distinct freezing zone was observed, and the curves were similar in shape to those previously published for cinnamon rolls *(7)*. Differences in freezing times between the 2 sizes of cake doughnuts, when frozen singly or in packages, were so small that average values are given in Table 2.

In freezing single unwrapped doughnuts of both types to 10° F without forced air circulation there is an advantage in operating the freezer at −10° F rather than at 0°, since time of freezing is reduced to approximately one-half by this temperature change. There appears to be no practical advantage in using a freezer temperature lower than −10° F unless the products are to be stored below 0° F. The same observations apply to packaged yeast-raised doughnuts. For packaged cake doughnuts the freezer temperature −20° F resulted in a material decrease in the time required for the temperature to reach 0° F. The desirability of using circulating air for rapid transfer of heat from the product is evident from the freezing times. At all temperatures the low air flow of 150 ft per min resulted in a great decrease in the freezing time of the unwrapped doughnuts from that required without circulating air. Higher rates of air flow gave, in general, only small further decreases with cake doughnuts.

Yeast-raised doughnuts with their more open cell structure showed an appreciable decrease in freezing time with air flow at 500 ft per min. The freezing time of packaged doughnuts was materially reduced by circulating air, although the proportionate reduction was far less than for the unwrapped. Increasing rates of air flow to the maximum of 1,000 ft per min caused appreciable decreases in freezing time.

Effect of temperature and air flow on rate of defrosting. For defrosting experiments the doughnuts were equilibrated 18 hr at 0° F. Defrosting time was taken as that required to raise the temperature from 0° to 70° F. Data for different conditions of temperature and air flow are given in Tables 4 and 5. As in freezing, the defrosting times of the 2 sizes of cake doughnuts, either unwrapped or packaged in the 2 types of box were so nearly the same that average values are given in Table 4. Without circulating air unwrapped doughnuts of both kinds were defrosted at 115° F in approximately one-half the time required at 75° F. At each temperature they defrosted much more rapidly when air was circulated at 150 ft per min. than without circulating air. This rate was evidently sufficient to supply heat to the surface of the doughnuts as rapidly as it could be absorbed, since increased rates of air flow had little additional effect.

Packaged doughnuts without circulating air defrosted at 115° F in less than half the time required at 75° F. At each temperature there was a material decrease in defrosting time as the rate of air flow was increased, to 500 ft per min. The further decrease in defrosting time when the rate of air flow was increased to 1,000 ft per min was comparatively small.

In these experiments the number of individual doughnuts or boxes which were processed at one time was relatively small and did not utilize the full space of freezer or defroster. In commercial production full utilization of space is to be expected. To attain the speed of processing of these experiments

TABLE 2

Time required to freeze cake doughnuts under varied temperature and air flow conditions

Freezer temperature	Freezing interval	Rate of air circulation, ft/min			
		0	150	500	1,000
Single, unwrapped					
°F	°F	Freezing time, min			
0	70 to 10	42	18	11.5	9.5
−10	"	23.5	....	....	....
−20	"	21	8.5	8.5	8
−10	70 to 0	43	....	....	....
−20	"	39	12.5	12.5	11
−20	70 to −10	84	18.5	19.5	15.5
Packaged					
0	70 to 10	106	89	70	65
−10	"	73.5	....	....	....
−20	"	56	47	47	35.5
−10	70 to 0	120	....	....	....
−20	"	90	73	70	46
−20	70 to −10	190	120	111	73

TABLE 3

Time required to freeze yeast-raised doughnuts under varied temperature and air flow conditions

Freezer temperature	Freezing interval	Rate of air circulation, ft/min			
		0	150	500	1,000
Single, unwrapped					
°F	°F	Freezing time, min			
0	70 to 10	29	12	9	8
−10	"	17	....	....	....
−20	"	15	8	6	4
−10	70 to 0	35	....	....	....
−20	"	34	18	7.5	7
−20	70 to −10	52	28	18	15
Packaged					
0	70 to 10	104	71	65	59
−10	"	64	....	....	....
−20	"	65	47	37	31
−10	70 to 0	121	....	....	....
−20	"	120	80	58	48
−20	70 to −10	181	129	116	101

TABLE 4

Time required to defrost cake doughnuts under varied temperature and air flow conditions

Defroster temperature °F	Rate of air circulation, ft/min			
	0	150	500	1,000
Single, unwrapped				
	Defrosting time, min (0° to 70° F)			
75	23	16.5	16.5	17
95	15.5	8.5	9	9
115	12	6.5	6.5	6
Packaged				
75	123.5	101	96.5	95.5
95	70	60.5	53.5	49.5
115	49	47.5	39.5	31.5

TABLE 5

Time required to defrost yeast-raised doughnuts under varied temperature and air flow conditions

Defroster temperature °F	Rate of air circulation, ft/min			
	0	150	500	1,000
Single, unwrapped				
	Defrosting time, min (0° to 70° F)			
75	24	19	20	19
95	17	11	10	9
115	12	7.5	6	5.5
Packaged				
75	110	93	69	69
95	61	56	43	33
115	49	44	34	30

at any given temperature the products must be spaced to permit air flow between the units, and the air flow rate must be sufficient to maintain the air at the surface of the unit at approximately the temperature of the freezer or defroster.

Effect of freezing and defrosting rates on freshness and firmness. To be in accord with commercial practice the doughnuts were packaged before freezing and the packages were opened immediately before testing. Storage effects were minimized by freezing the doughnuts 2 hr after frying, and defrosting them as soon as possible after equilibrium at 0° F had been attained. The total elapsed time from frying to testing the defrosted doughnuts was approximately 20 hr. Data for changes in freshness and firmness are given in Table 6. Two hr after frying, both types of doughnuts were rated *fresh* by the panel (ratings 7.0 to 7.1). Freezing and defrosting lowered the rating to *moderately fresh*, approximately 6. This lowering of freshness is at the borderline of significance at the 5% level. Within the limits employed, differences in freezing and defrosting times had little effect on freshness ratings. There was no observed increase in firmness when cake doughnuts were frozen and defrosted rapidly. Under the other conditions the increase in firmness was very small. Freezing and defrosting had a greater effect on the firmness of yeast-raised doughnuts. However, the increase was significant at the 5% level only when freezing, or both freezing and defrosting were slow. These effects are similar to those found for other bakery foods richer than bread *(8, 10)*.

Frozen and defrosted doughnuts were far less firm than those stored for 24 hr at 70° F. Under these conditions the firmness of both kinds of doughnuts increased to nearly the same value, 92 to 96 g per square inch. This increase in firmness appears to have had comparatively little effect on the freshness rating given the cake doughnuts. They were rated 5.5, between *moderately fresh* and *slightly fresh*, a rating not significantly lower than that of the frozen and defrosted doughnuts. The freshness rating of yeast-raised doughnuts stored at 70° F for 24 hr was greatly lowered, to 3.6, between *slightly stale* and *moderately stale*. This shows that they were no longer considered palatable. Considering both freshness ratings and firmness, it appears advantageous to freeze both types of doughnuts unless they are to be consumed on the day they are fried.

Moisture loss on freezing and defrosting unwrapped doughnuts. Loss of moisture from bakery foods is always undesirable because it is interpreted as loss of freshness. Bechtel and Meisner *(3)* showed that loss of 2% moisture from bread caused a significant decrease in freshness, and Kulp, Ponte, and Bechtel *(9)* have shown that moisture loss causes rapid staling of white and yellow layer cakes. Measurements of moisture loss during freezing were made at freezer temperatures of 0° and −20° F with air flow rates of 0, 150, 500 and 1,000 ft per min. The time during which moisture loss was measured was that required to lower the temperature from 70° to a temperature 10° F above that of the freezer. Neither type of doughnut lost appreciable moisture and no relationship could be found between the slight changes in moisture and either freezer temperature or rate of air flow. This would be expected, since the surface of the doughnuts was cooled rapidly with resulting rapid lowering of the vapor pressure of the water. Where the greatest possible speed of freezing is desired it appears entirely practical to freeze doughnuts unwrapped.

Moisture losses on defrosting unwrapped doughnuts from 0° to 70° F were determined at defroster temperatures of 75°, 95° and 115° F and with the same air flow rates as during freezing. Results are shown in Table 7. In these experiments relative humidity was not controlled. It was 54%–58% at 75° F, 35%–40% at 95° F, and 28%–30% at 115° F. Pence, Standridge and Copley *(12)* in their study of the defrosting of unwrapped bread, found that gain or loss of moisture depended on air temperature, relative humidity, and time of exposure. They found also that at low air velocity the best relative humidity for minimizing moisture change was near 50%. The present experiments show that these findings apply also to doughnuts. At 75° F, with relative humidity near 50%, there was only a small change in moisture. With increase in temperature of the defrosting atmosphere and with increase in air velocity there is a trend toward higher moisture loss.

Exposure of the doughnuts to the atmosphere of the defroster for 30 min longer than required for their temperature to reach 70° F caused much greater moisture losses. Values are given in Table 7 to emphasize the necessity of controlling time of exposure, especially if operating at higher temperatures and air velocities.

Effect of storage temperature on freshness and firmness. Doughnuts used for this study were packaged in the boxes to duplicate commercial conditions and to insure against moisture loss. They were frozen at −20° F with air flow at 1,000 ft per min., and defrosted at 75° F without circulating air. Data for cake doughnuts are given in Table 8. Freshly fried cake doughnuts were rated *fresh* (6.9) by the panel and their firmness was 45 g per sq in. The effect of freezing and defrosting is shown by the freshness rating and firmness at 1 day at 0° F. Freshness ratings after storage for 7 days were essentially the same, regardless of storage temperature, and showed little effect beyond that caused by freezing and defrosting. There was a significant increase in firmness, however, at both 20° and 10° F. By the 14th day of storage the freshness rating was significantly lowered at 20° and 10° F, and the firmness had increased further. At 0° and −20° F the decrease in freshness was slow, and did not become significantly lower than that caused by freezing and defrosting until the 21st day. Storage

TABLE 6

Effect of time of freezing and defrosting on the freshness and firmness of doughnuts

Rate of freezing[1]	Rate of defrosting[1]	Freshness rating[2]	Firmness g/sq in
Cake doughnuts[3]			
Freshly fried		7.1	45
Rapid	Rapid	6.1	45
Rapid	Slow	6.2	49
Slow	Rapid	5.9	51
Slow	Slow	6.2	48
After 24 hr at 70° F		5.5	92
Yeast-raised doughnuts[4]			
Freshly fried		7.0	31
Rapid	Rapid	6.1	36
Rapid	Slow	6.2	35
Slow	Rapid	6.0	41
Slow	Slow	5.8	43
After 24 hr at 70° F		3.6	96

[1] Rapid rate: freezing at −20° F, defrosting at 115° F. Air flow 1,000 ft per min. Slow rate: freezing at 0° F, defrosting at 75° F. Without forced air.

[2] Rating scale: *Very fresh* 8, *fresh* 7, *moderately fresh* 6, *slightly fresh* 5, *slightly stale* 4, *moderately stale* 3, *stale* 2, *very stale* 1.

[3] Minimum significant difference at 5% level: freshness rating, 1.0; firmness 9.8.

[4] Minimum significant difference at 5% level: freshness rating, 1.1; firmness 7.2.

TABLE 7

Change in moisture of unwrapped doughnuts under varied defrosting conditions

Rate of air circulation ft/min	Defroster temperature, ° F					
	75°		95°		115°	
	Moisture change, %					
	(1)	(2)	(1)	(2)	(1)	(2)
Cake doughnuts						
0	0.2	−0.5	0.1	−1.3	−0.5	−3.3
150	0.4	−0.8	0.1	−1.2	−0.8	−3.3
500	−0.3	−1.4	−0.6	−2.5	−0.6	−4.4
1,000	−0.5	−1.8	−0.6	−3.5	−0.7	−4.8
Yeast-raised doughnuts						
0	0.2	−0.3	−0.3	−2.7	−0.9	−3.7
150	0.2	−1.2	−0.5	−3.0	−0.6	−4.4
500	0.6	−1.1	−0.9	−3.5	−1.7	−6.5
1,000	−0.4	−1.9	−0.8	−4.1	−1.1	−5.9

(1) = Time in defroster equals defrosting time shown in Tables 4 and 5.

(2) = Time in defroster equals defrosting time plus 30 min.

TABLE 8

Effect of storage time and temperature on the freshness and firmness of cake doughnuts

Days in storage	Temperature of storage, °F				
	70	20	10	0	−20
Freshness rating[1]					
0	6.9	6.9	6.9	6.9	6.9
1	5.5	....	....	6.2	....
7		5.9	5.8	6.0	6.0
14		5.1	5.3	5.8	5.6
21		4.6	4.6	5.3	5.5
56		....	....	5.3	....
Firmness, grams per square inch[2]					
0	45	45	45	45	45
1	92	....	....	49	....
7		79	78	52	52
14		125	87	55	51
21		106	89	49	46
56		....	....	73	....

[1] For rating scale see Table 6, footnote 2. Minimum significant difference at 5% level = 0.6.

[2] Minimum significant difference at 5% level = 13.6.

for 56 days at 0° F caused no further decrease in freshness rating. At 0° and −20° F the firmness remained essentially constant for 21 days, but increased significantly after 56 days at 0° F.

At both 20° and 10° F yeast-raised doughnuts staled and firmed rapidly, as shown in Table 9. After storage for 7 days they were rated *slightly stale*, indicating that they were not acceptable to the panel, and they had firmed slightly more than those at 70° F for 1 day. In contrast, there was little evidence of staling or firming in 21 days at 0° or −20° F, or in 56 days at 0° F.

Within the limits of storage time of these experiments 0° F appears to be adequately low for preservation of freshness and prevention of undue firming. Above this temperature there is a significant increase in the firmness of both types of doughnuts and significant loss of freshness by yeast-raised doughnuts, within 7 days. Freshness ratings and firmness values were no better at −20° F than at 0° F.

SUMMARY

In the freezing of packaged doughnuts, forced air circulation at rates exceeding 500 linear ft per min do not appear to produce additional benefits in lowered rate of freezing. For doughnuts to be stored at 0° F, freezer temperatures of −10° F or −20° F will materially lower the freezing time. There is a material gain in speed of defrosting through use of elevated temperature (115° F) and forced air circulation at 500 ft per min. Freezing and defrosting lowered the freshness of doughnuts, but had far less effect than standing at room temperature for 24 hr. Within the limits employed, differences in freezing and defrosting time had only minor effects on freshness or firmness of doughnuts. If speed of freezing is of major importance, doughnuts may be frozen unwrapped with little moisture loss. Appreciable moisture loss occurs during defrosting of unwrapped doughnuts and this practice is not recommended. For frozen storage the temperature 0° F appears adequately low. Above this temperature doughnuts become stale and firm rather rapidly.

TABLE 9

Effect of storage time and temperature on the freshness and firming of yeast-raised doughnuts

Days in storage	Temperature of storage, °F				
	70	20	10	0	−20
Freshness rating[1]					
0	7.1	7.1	7.1	7.1	7.1
1	3.6	....	....	6.2	....
7		3.9	4.2	5.9	6.3
14		2.7	3.7	5.9	6.8
21		2.5	3.5	5.9	5.9
56		....	....	5.9	....
Firmness, grams per square inch[2]					
0	31	31	31	31	31
1	96	....	....	35	....
7		101	101	37	34
14		122	114	38	37
21		120	121	40	37
56		....	....	38	....

[1] For rating scale see Table 6, footnote 2. Minimum significant difference at 5% level = 0.8.

[2] Minimum significant difference at 5% level = 14.6.

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The Utilization of Ionizing Radiation to Increase the Storage Life of White Potatoes[a]

M. Workman, M. E. Patterson,[b] N. K. Ellis, and F. Heiligman[c]

(Manuscript received April 12, 1960)

INITIAL WORK on the influence of ionizing irradiation on white potatoes by Sparrow and Christensen *(7)* created considerable interest in the possible utilization of irradiation to increase the storage life of potatoes. Excellent control of sprouting with no deleterious side effects was obtained with dosages as low as 5.0 kilorep.[d]

The inhibition of sprouting was confirmed by a number of workers *(1, 3, 5, 6, 7)*. Concomitant with sprout reduction, weight loss and shriveling were reduced *(1, 5)*. Other investigations revealed that dosages of 20 and 80 kilorep [d] did not increase diffusion of nutrients from wounds or influence the rate of maceration of potato flesh by certain bacterial soft rot organisms *(9)*. However, periderm formation was prevented by the 20 and 80 kilorep [d] dosages, and even dosages as low as 2.5 kilorep [d] interfered with normal periderm development *(1)*. Suberin development, although retarded initially by irradiation, soon compared favorably with controls *(1)*. Whether irradiation in the dosages required for sprout inhibition increases or decreases the rate of potato flesh breakdown by micro organisms is still undecided *(2, 4)*.

In the first large scale experiment involving some 20 to 25,000 pounds each of two varieties the results were extremely discouraging *(6)*. The irradiated potatoes decayed more rapidly than the controls. Two dose ranges were used, 15–22,000 and 30–44,000 kilorep.[d] The irradiation was accomplished with spent fuel rods at Idaho Falls, Idaho and the potatoes were stored for observations in nonrefrigerated storages in Maine. Consequently, the potatoes received considerable handling before and after irradiation.

The studies reported in this paper had the following objectives: to study the influence of dosages ranging from 0 to 15 kilorep [d] on four varieties each grown in a different geographical region within the United States; to determine the value of different curing methods; and to determine the influence of delaying the exposure to ionizing radiation. Coordinated studies dealing with storage rot susceptibility of these potatoes were conducted at Michigan State University *(2)*.

MATERIALS AND METHODS

The 4 potato varieties were grown in the following locations: Sebago—muck soil, North Judson, Indiana; Red Pontiac—muck soil, Hollandale, Minnesota; Katahdin—Presque Isle, Maine; and Russet Burbank, Blackfoot, Idaho. All were U. S. No. 1 grade. Shortly after harvest the potatoes were shipped to Lafayette, Indiana, and placed at 47° F until treatment. The potatoes were irradiated with gamma rays from Cobalt 60 at the Fission Products Laboratory, University of Michigan, Ann Arbor, Michigan.

The studies were divided into two parts. In Part I, attention was centered on determining the optimum irradiation dosage and method of curing and in Part II, the major emphasis was to determine the best time to irradiate.

In Part I, dose levels of 0, 5.0, 7.5, 10.0, 12.5, and 15.0 kilorep were employed. The potatoes were irradiated in heavy cardboard experimental boxes each of which contained about ten pounds of potatoes. The boxes were fitted with a cover and placed on their side around the source. One half of the dosage was applied to one side. The boxes were then reversed for the remainder of the dosage. An error in dose level of plus 5% was estimated, e.g., 5.0 kilorep = 5.0 − 5.25 kilorep.

Prior to irradiation the Sebago variety was divided into 4 equal lots. One lot was not intentionally cured. A second lot was cured at 70° F and high relative humidity for about 7 days immediately *after* irradiation. A third lot was cured similarly before irradiation. And a fourth lot was cured both before and after irradiation. These curing treatments will be referred to as no cure, post-cure, pre-cure and pre-and post-cure, respectively.

Since it was impossible to avoid some curing during shipment of Red Pontiac, Katahdin, and Russet Burbank potatoes, only the pre-cure and the pre-and post-cure treatments were employed.

The bulk of the experiment and the distance to the irradiation source precluded irradiation at one time. Table 1 summarizes the harvest dates and the dates of irradiation of the potatoes used in Part I. Following treatment, the potatoes in Part I were stored at 41° F and 55° F and a relative humidity generally above 85%. Initially all treatments were replicated 8 times with each replication containing about 10 lb. After about one year of storage 4 replications were no longer periodically weighed but were used for destructive samplings. When the potatoes were destructively sampled observations for internal discoloration and rate of raw darkening were made.

TABLE 1

The date of harvest and the date of irradiation of the potatoes used in part one of the studies

Variety	Date	
	Harvested	Irradiated
Sebago	Nov. 5, 1956	Dec. 4, 1956
Red Pontiac	Oct. 10, 1956	Dec. 18, 1956
Katahdin	Sept. 25, 1956	Jan. 2, 1957
Russet Burbank	Oct. 17, 1956	Jan. 2, 1957

[a] Journal paper No. 1573 of the Purdue Agricultural Experiment Station. This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, Qm. Research and Engineering Command, U. S. Army, and has been assigned number 1092 in the series of papers approved for publication.

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[c] Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois.

[d] 1 kilorep = 0.93 kilorad.

Limited cooking tests were made on certain treatments after various periods of storage. Decay was measured by weighing and tuber counts. There was good agreement between the two measurements; therefore, for brevity the decay data reported is based on tuber count.

In Part II, the same 4 varieties were used. However, only 4 levels of gamma radiation were employed: 0, 7.5, 10.0, and 12.5 kilorep. The potatoes were only cured prior to irradiation. The original plan in Part II was to irradiate immediately after harvest, again about the mid-point in the dormancy period and again after the end of the dormancy period. However, due to various difficulties the first irradiation was not done until December 4, 1956; the second irradiation was on January 3, 1957 and the third irradiation on January 30, 1957. The potatoes were stored at 47° F prior to and after irradiation.

RESULTS

Due to its bulk, no attempt will be made to present all of the data obtained. Rather, certain key figures have been selected which illustrate, for the most part, the important features of the results.

Sprouting observations: A dosage of 5 kilorep prevented sprouting of Sebago, Katahdin and Russet Burbank potatoes stored at 41° F. Complete sprout inhibition of Red Pontiac potatoes at 41° F required 7.5 kilorep. The lowest dosage employed at 47° F, 7.5 kilorep, prevented sprouting on all 4 varieties. In 55° F storage, 7.5 kilorep inhibited sprouting of Sebago, Katahdin, and Russet Burbank but Red Pontiac required 12.5 kilorep for complete inhibition, although practical control was obtained with 10.0 and even 7.5 kilorep.

Decay observations: The rate of decay at 41° F of Sebago potatoes was influenced by curing treatment (Figure 1). Irradiated potatoes which were not cured decayed most rapidly, and the pre- and post-cured potatoes had the lowest decay rate. Potatoes pre-cured and post-cured were intermediate in decay rate and decayed at the same rate.

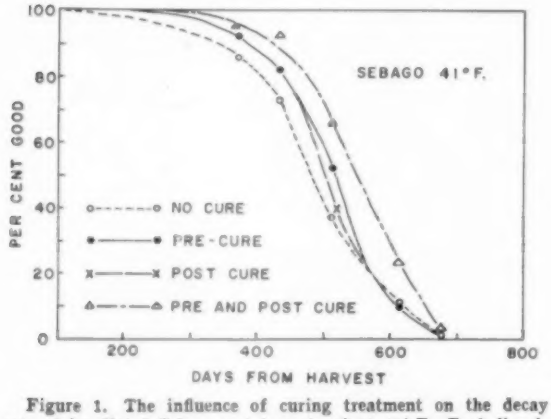

Figure 1. The influence of curing treatment on the decay rate of irradiated Sebago potatoes stored at 41° F. Each line is an average of 5 irradiation treatments.

In contrast to Sebago, the other 3 varieties stored at 41° F decayed at the same rate whether pre-cured alone or pre- and post-cured.

In 55° F storage, differences in the decay rate between curing treatments were minor.

The influence of irradiation dose level on the decay rate at 41° F is illustrated for Sebago potatoes in Figure 2. Between 85 and 95% of the Sebago potatoes were still intact 400 days after harvest. At this time decay was slightly greater in the 12.5 and 15.0 kilorep treatments than in the controls and lower dosages. Beyond 400 days decay proceeded rapidly in all treatments. Essentially the reaction of the other varieties to dose level was similar although the sharp increase in decay rate occurred sometime after 400 days (see below).

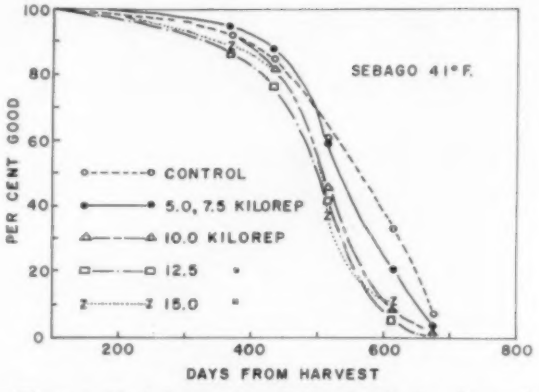

Figure 2. The influence of irradiation dose level on decay rate of Sebago potatoes stored at 41° F. Each line is an average of the 4 curing treatments.

The typical effect of dose level on decay at 55° F is illustrated by the response of Katahdin potatoes (Figure 3). Decay was minor in all treatments up to 300 days at 55° F. Beyond this period, decay proceeded rapidly and at about the same rate in all treatments.

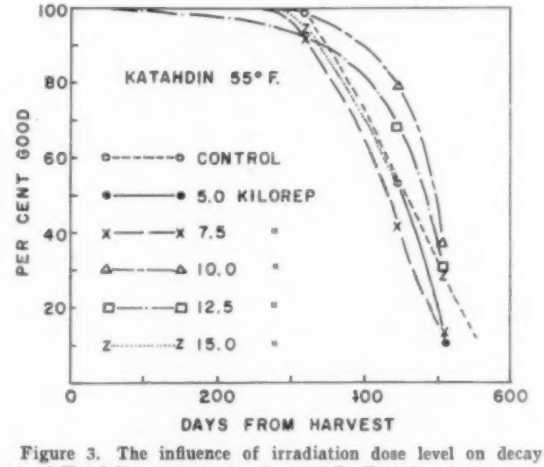

Figure 3. The influence of irradiation dose level on decay rate of Katahdin potatoes stored at 55° F. Each line is the average of two curing treatments.

Figure 4 illustrates the average decay rate of all sprout inhibitory irradiation treatments and respective controls of the 4 varieties at 41° F. Control and irradiated Sebago potatoes decayed at the same rate. Russet Burkank reacted similarly, but rapid decay did not occur until after 600 days. Irradiated Katahdins decayed slightly faster than their controls. For example, at 500 days 98% of the control potatoes remained and 89% of the irradiated. Conversely, irradiated Red Pontiac potatoes decayed more slowly than the controls; after about 550 days in storage about 75% of the controls remained and 90% of the irradiated.

The average decay rate of all sprout inhibitory irradiation treatments and respective controls of the 4 varieties at 55° F is shown in Figure 5. Decay was negligible up to about 275–300 days from harvest with the exception of the Red Pontiac controls. These sprouted heavily and decayed early in the test (not shown on figure). Beyond 275–300 days from harvest,

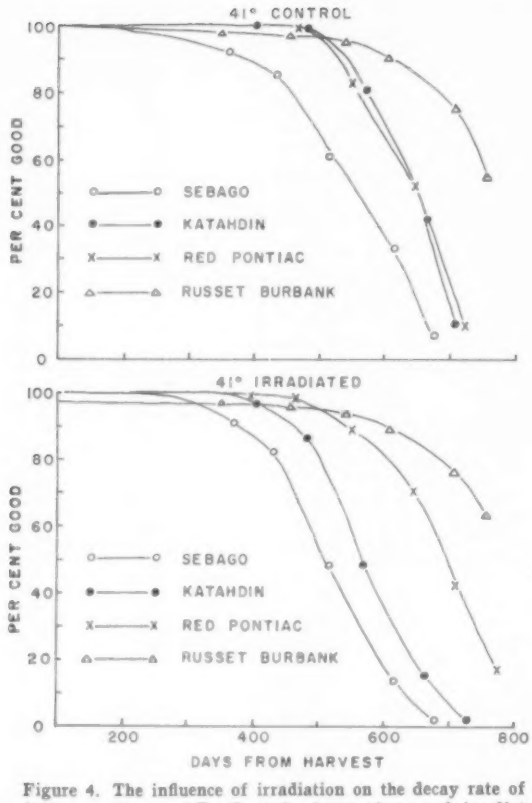

Figure 4. The influence of irradiation on the decay rate of 4 varieties stored at 41° F. Controls shown above and irradiated below. Each line is an average of all curing treatments and the sprout inhibiting dosages.

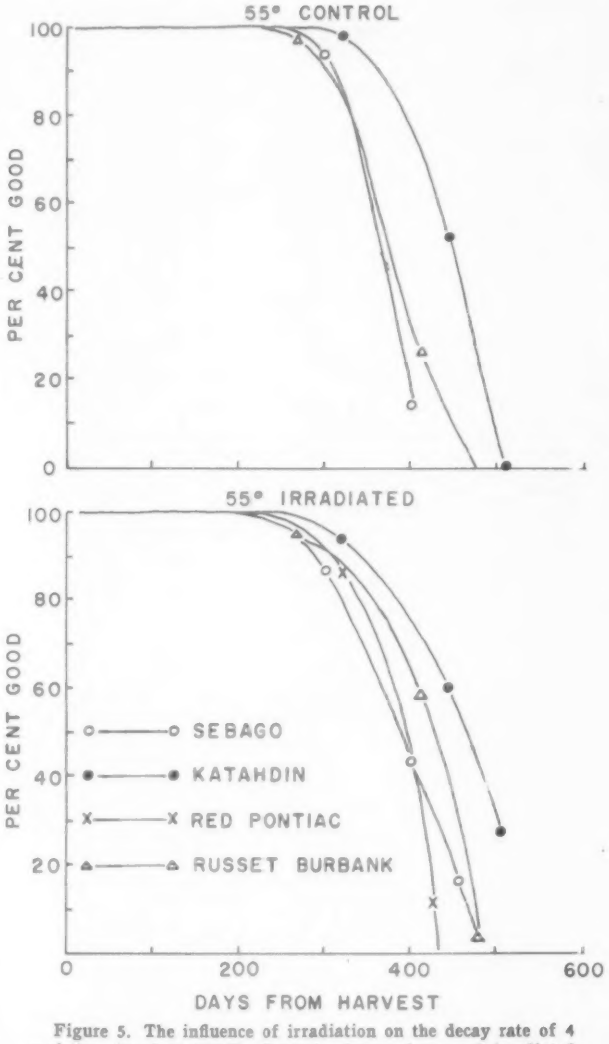

Figure 5. The influence of irradiation on the decay rate of 4 varieties stored at 55° F. Controls shown above and irradiated below. Each line is an average of all curing treatments and the sprout inhibiting dosages. Red Pontiac controls decayed early in the study and are not shown.

decay proceeded rapidly and at similar rates in the irradiated and control potatoes of the other 3 varieties.

Delaying the time of irradiation did not influence decay rate (Figure 6). Although the figure presented is for Sebago potatoes, it is representative of the other 3 varieties. Decay rate of the irradiated potatoes was similar regardless of the date of irradiation. Also, it should be noted that the decay rate of the non-irradiated potatoes was slightly more rapid than that of the irradiated potatoes.

Weight loss observations: Weight loss of Sebago potatoes stored at 41° F was influenced by curing treatment (Figure 7). By a considerable margin pre- and post-cured potatoes lost weight most slowly. Non-cured potatoes lost weight most rapidly. Potatoes post-cured or pre-cured exhibited an intermediate rate of weight loss. In contrast to Sebago, rate of weight loss of the other varieties was similar following both the pre-cure and pre- and post-curing treatment. However, the rate of weight loss of the respective varieties differed considerably (see below).

Weight loss at 55° F was not influenced markedly by curing treatment. Sebago potatoes lost weight most slowly following the pre-cure treatment. Non-cured Sebago tubers lost weight most rapidly and an intermediate rate of weight loss was shown by potatoes either post-cured or pre- and post-cured. The other 3 varieties lost weight at the same rate following either the pre-cure or pre- and post-curing treatments.

The rate of weight loss at 41° F was similar following the 5 levels of radiation except where sprouting occurred. Irradiated tubers and their respective controls also lost weight at similar rates for considerable periods at 41° F (Figure 8). Not until the controls sprouted was there a deviation in the rates of weight loss. This occurred at about 200, 300, 300 and 350 days, respectively, for the varieties Red Pontiac, Sebago, Katahdin and Russet Burbank. A rather striking difference in the rate of weight loss at 41° F occurred between varieties. For example, at 400 days, irradiated Russet Burbank potatoes had lost only 5% of their initial weight, Red Pontiac—7.5%, Katahdin —10%, Sebago 16%.

Differences in the rates of weight loss following the 5 levels of irradiation were more striking at 55° F than at 41° F due to more vigorous sprouting in certain treatments. This is vividly illustrated by the response of Red Pontiac potatoes (Figure 9). The rate of weight loss was proportional to the degree of sprouting. 12.5 and 15.0 kilorep completely inhibited sprouting and gave the lowest rate of weight loss. As dosage was decreased below 12.5 kilorep, the rate of weight loss increased. The controls showed the highest rate of weight loss. The rapid increase in the rate of weight loss of the 12.5 and 15.0 kilorep treatments after about 250 days at 55° F was due to an increase in the rate of decay.

The average rate of weight loss at 55° F of the non-sprouted irradiated potatoes and their controls is shown in Figure 10.

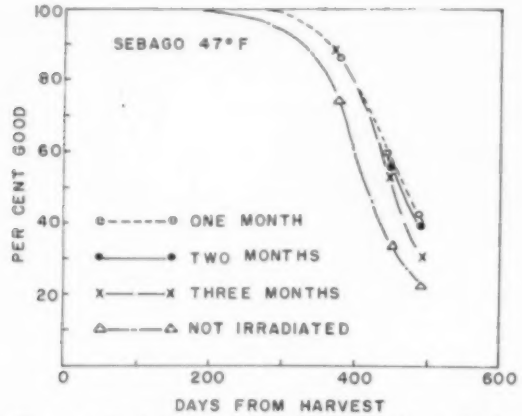

Figure 6. The influence of the date of irradation on the decay rate of Sebago potatoes stored at 47° F. Each line for the irradiated potatoes is an average of 3 irradiation dosages. In the legend, one month, 2 months, and 3 months refers to the time of irradiation following harvest.

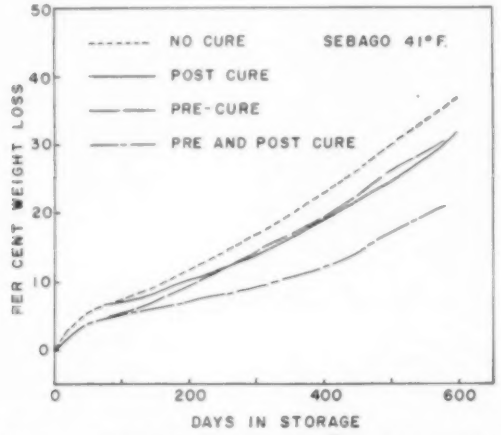

Figure 7. The influence of curing treatment on the weight loss of irradiated Sebago potatoes stored at 41° F. Each line is an average of the 5 irradiation treatments.

Up to 25 or 50 days after the beginning of storage at 55° F controls and the respective irradiated potatoes lost weight at a similar rate. Sprouting then commenced in the controls increasing their rate of weight loss beyond that of the respective irradiated potatoes. Between 200 and 300 days, depending upon the variety, the onset of heavy decay increased the rate of weight loss of the irradiated potatoes rather markedly.

The date of irradiation did not markedly change the rate of weight loss of Sebago potatoes stored at 47° F (Figure 11). Although Sebago potatoes irradiated approximately 3 months after harvest lost weight somewhat more rapidly than those irradiated earlier, the other 3 varieties showed even less differences in the rate of weight loss between the 3 dates of irradiation. The non-irradiated potatoes at 47° F lost weight at the same rate as the irradiated potatoes until sprouting commenced. The time when this occurred differed with the variety and varied between 100 and 160 days.

DISCUSSION

The observations on decay of irradiated potatoes in these studies are essentially in agreement with the studies of Duncan, Hooker and Heiligman *(2)* and

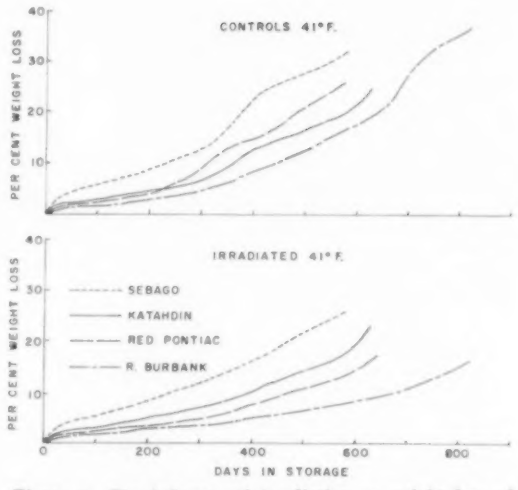

Figure 8. The influence of irradiation on weight loss of 4 varieties stored at 41° F. Controls shown above and irradiated below. Each line is an average of all curing treatments and all sprout inhibiting dosages.

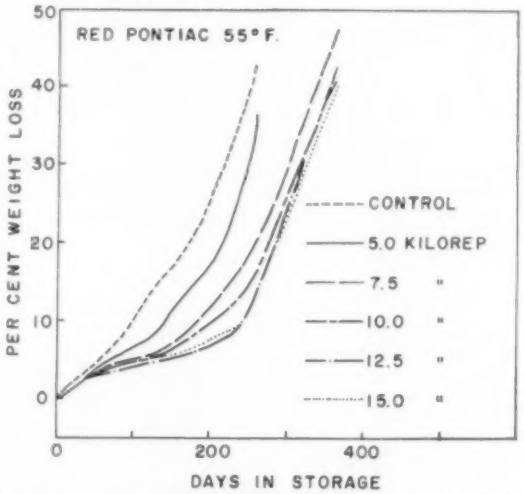

Figure 9. The influence of irradiation dose level on weight loss of Red Pontiac potatoes at 55° F. Each line is the average of two curing treatments.

Hooker and Duncan *(4)*. In the studies of Duncan *et al* decay incidence of potatoes irradiated in January following harvest and neither intentionally wounded nor inoculated was minor and did not increase with increasing irradiation dosages from 5 to 15.0 kilorep. Decay evaluation was made after either a 30- or 90-day period at 68°–70° F. In the studies of Hooker and Duncan *(4)* dosages of 0 and 12 kilorep resulted in the same decay rate of Sebago potatoes which were not intentionally wounded or inoculated. The latter observations were made over a period of 129 days at 68°–70° F and also over 365 days at 34°–40° F.

Although decay was not accelerated by the irradiation dosages employed in these studies a word of

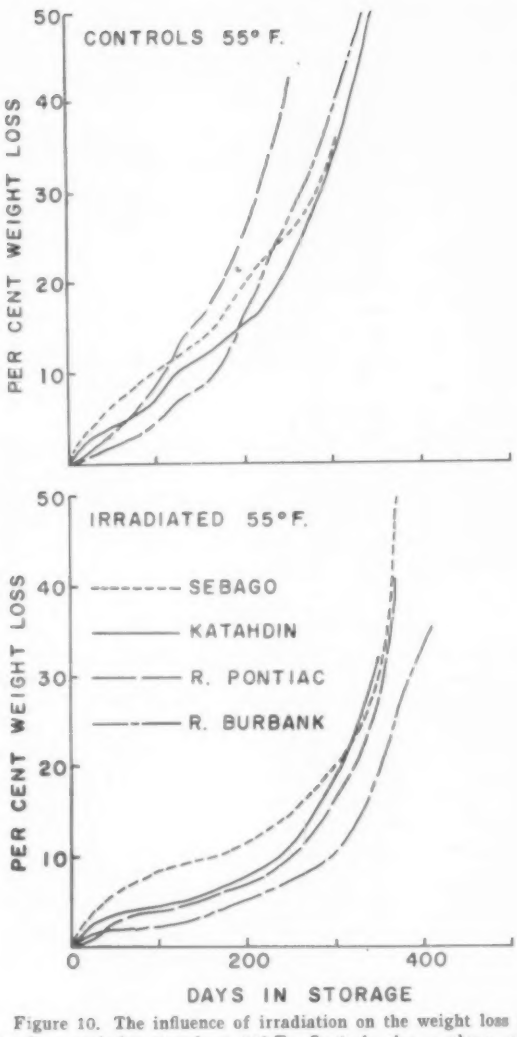

Figure 10. The influence of irradiation on the weight loss of the four varieties stored at 55° F. Controls shown above and irradiated below. Each line is an average of all curing treatments and the sprout inhibiting dosages.

caution should be given. Care should be exercised in handling irradiated potatoes. In these studies the potatoes were contained in boxes whereas commercially for the most part they are not. This need for careful handling was emphasized by the studies of Duncan *et al (2)*. Wounded and inoculated tubers generally showed increasing decay incidence with increasing dosage.

The reduction in the rate of weight loss due to irradiation was most likely only due to sprout inhibition. For example at 41° F weight loss of the controls prior to sprouting and weight loss of the irradiated potatoes was identical. Brownell *(1)* suggested that irradiation may have an influence on the cells per se in reducing weight loss. However, this hypothesis was based upon observations of potatoes treated at higher dose levels (above 20.0 kilorep).

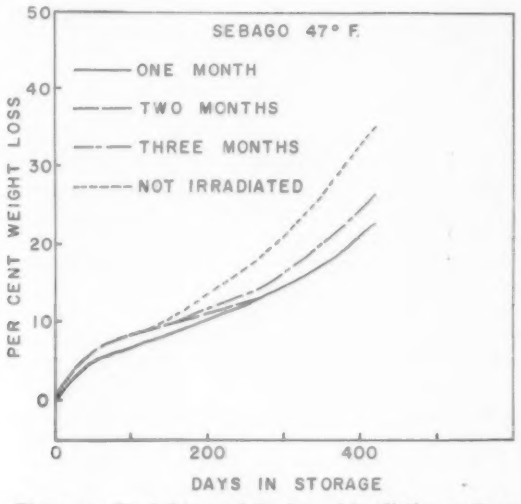

Figure 11. The influence of the date of irradiation on the rate of weight loss of Sebago potatoes stored at 47° F. Each line for the irradiated potatoes is an average of 3 irradiation dosages. In the legend, one month, 2 months, and 3 months refers to the time of irradiation following harvest.

The beneficial effect of curing both on lessening decay (Figure 1) and more strikingly on reducing the rate of weight loss (Figure 7) of Sebago potatoes emphasizes the importance of curing. The variety Sebago was unique among the varieties studied in that the pre- and post-treatment was particularly outstanding in retarding weight loss. In the case of the other varieties no difference in weight loss existed between the pre-cure and the pre- and post-curing treatment. Although periderm formation is inhibited by irradiation *(1)* suberin deposition and possibly other protective mechanisms are not. That the Sebago variety may be capable of developing protective mechanisms following irradiation was indicated by the work of Hooker and Duncan *(1)*. For example holding cut and wounded Sebago tubers 3 days at 70°–75° F following dosages from 5 to 15 kilorep prevented any disease incidence even though the tubers were dipped in an inoculum either of *Fusarium sambucinum* or *Eriwinia carotovora*. Dipping within 6 hr of irradiation gave a high disease incidence.

The time of irradiation (December 4, January 4, or January 31) did not influence weight loss or decay incidence. If irradiation had been delayed until April or July, an increase in decay incidence may have occurred. Duncan *et al (2)* observed a higher decay incidence in non-wounded and non-inoculated Sebago potatoes irradiated in April and July than when irradiated in January or early February. In all probability it would be desirable to irradiate as soon as possible after harvest and a suitable curing period.

The fact that irradiated tubers did not break down during prolonged storage periods in these studies should not infer that normal physiological deterioration was not occurring. Limited cooking tests indicated a reduction in desirable cooking characteristics.

Irradiated tubers stored two years at 41° F contained about 2.3% reducing sugars. At this time suitable controls were not available for analysis. After two weeks at 68° F the reducing sugar content dropped to 1.2% but an additional two weeks at 68° F failed to bring a further reduction. Internal color changes from white to gray also occurred during prolonged storage. Darkening rate of cut tubers also increased. This was related directly to tuber turgidity. Hence controls often darkened more rapidly than irradiated potatoes. The physiological disorder known as black spot was not observed to any extent.

To assess a value to the actual extension of storage life at the three experimental temperatures would have demanded a consideration of all the factors listed above and perhaps others as well. However, an approximation of the extension of storage life may be obtained if we use the following criteria for the termination of storage life: For the controls—that time when their weight loss had exceeded that of the non-sprouted irradiated potatoes by 2.5% and for the irradiated when decay had reached 15%. The values obtained by averaging data for the 4 varieties is summarized in Table 2. It is clear that the benefit from irradiation rapidly diminishes with decreasing storage temperature.

TABLE 2

Influence of gamma irradiation on the average storage life of four varieties of white potatoes stored at three temperatures

	Storage life from harvest		
Storage temperature	Controls[1]	Irradiated[2]	% Increase
55° F.	141 days	303 days	114
47° F.	251 days	414 days	65
41° F.	454 days	580 days	28

[1] Time when weight loss exceeded that of irradiated potatoes by 2.5%.

[2] Time when decay had exceeded 15%. Beyond this time it would not have been economically sound to market the potatoes.

SUMMARY

Observations were made on sprouting, rate of decay and weight loss of 4 varieties of white potatoes which were exposed to 5, 7.5, 10.0, 12.5, and 15.0 kilorep of gamma radiation. Various curing treatments and dates of irradiation were also studied. Three experimental temperatures were used: 41°, 47°, and 55° F.

Sprouting of Sebago, Russet Burbank and Katahdin potatoes stored at 41° F was prevented by 5.0 kilorep. The fourth variety, Red Pontiac, required 7.5 kilorep. At 47° F sprouting of all varieties was prevented with 7.5 kilorep. At 55°, Red Pontiac required 12.5 kilorep for complete inhibition although 10.0 and even 7.5 kilorep gave practical control. Sprouting of other varieties at 55° F was prevented by 7.5 kilorep.

Irradiation reduced the rate of weight loss in proportion to the relative reduction in sprout growth. Hence the most spectacular results were at 55° F.

Increasing the irradiation dose from 5.0 to 15.0 kilorep did not in general increase the decay rate. At 55° F the intermediate dose levels of 7.5 and 10.0 kilorep gave slightly lower decay rates.

Any curing treatment was beneficial but the most desirable seemed to be curing before irradiation. With the exception of the variety Sebago curing again following irradiation gave no additional benefit.

Potatoes irradiated one, two or three months after harvest reacted similarly.

Although irradiated potatoes remained quite free from decay for extremely long periods when not subjected to excessive handling (up to an average of 580 days at 41° F) limited cooking tests and other observations indicated that a gradual reduction in quality was taking place.

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Interior Physical Quality and Bacterial Contamination of Market Eggs as Influenced by Egg Shell Permeability[a]

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THE RELATIONSHIP between egg shell permeability and interior physical quality *per se* has not been reported. Indirect approaches to this association have been made by dealing with the influences of environment, e.g. temperature, humidity and washing, on weight loss and resultant interior physical quality. These works have been reviewed by Romanoff and Romanoff *(12)*, Korslund *et al (7)*, Fromm and Margolf *(3)* and Mueller *(11)*.

Kraft *et al (8)* reported a significant relationship between egg shell permeability and bacterial contamination. However, Mountney and Vanderzant *(10)* reported that there was little if any correlation between egg shell permeability and bacterial contamination. Both groups of workers used the subjective method of Almquist and Holst *(1)* for evaluating egg shell permeability. The purpose of the present study was to determine whether a correlation exists between egg shell permeability and resultant interior physical quality of egg contents and bacterial contamination by employing an objective colorimetric method *(4)* for determining egg shell permeability.

EXPERIMENTAL

General. Eggs used in this study were obtained from a flock of Single Comb White Leghorns in their initial year of production. They were gathered 3 times daily from the flock, and the eggs employed were visibly clean and weighed 59–64 g each. This study was carried out in 2 parts. In Part I, the influence of shell permeability on interior physical quality was determined and in Part II the relationship between egg shell permeability and bacterial contamination of the egg contents was evaluated. Egg shell permeability was determined according to the method of Fromm *(4)* with the exception that in the present study permeability was determined on an individual rather than on a paired egg basis. All data were analyzed statistically.

Part I—Interior Physical Quality

Fromm *(5)* reported that washing and age affected the permeability of the egg shell. Hence, in order to provide several different levels of permeability on the day that the eggs were gathered, eggs with an internal temperature of 75° F were either washed in 75° F water for 3 min or washed in 110° F water for the same time and the moist eggs rubbed with a cheese cloth. The eggs were then held for 8 days at 74° F and 55% R. H. in open molded pulp cartons. Thirty-two eggs were removed from each treatment at 2-day intervals during the 8-day storage period and analyzed for egg shell permeability and interior physical quality. Interior physical quality was determined objectively and the numerical scores were designated as *Haugh units (2, 6)*. A control group of unwashed eggs was carried through the experiment.

Part II—Bacterial Contamination

Eggs used in this study were treated in the same manner as those used for the interior quality study (unwashed, washed at 75° F, and washed at 110° F and rubbed on the day of gathering) and held for 5 hr at 75° F after washing. Forty-eight eggs within each treatment were dipped in a 48-hr, 75° F, nutrient broth culture of *Pseudomonas aeruginosa* for 5 min on the initial day of storage, placed in molded pulp cartons and incubated at a mean temperature of 79° F for 25 days. The eggs were candled daily with ultra violet light to determine the presence or absence of green pigmentation in the egg contents. Green fluorescence was used as an indicator for designating spoilage.

RESULTS AND DISCUSSION

The influence of egg shell permeability on interior physical quality is presented in Figure 1. The various treatments caused detectable differences in shell permeability. Haugh unit score differences between treatments were found to be related to permeability of the egg shell. Significant correlations were evident between shell-permeability and interior physical quality in control and 75° F washed groups. The degree of relative variability for optical density of shell extractions (permeability) and interior physical quality observations are shown in Table 1. Mean coefficients of variation, according to age groups, were relatively similar among Haugh unit scores, with a range of 4.31% between the low of the control and high of the 75° F washed treatments. The range in shell treatment coefficients of variation was 22.58% for optical density determinations. A trend is indicative among the optical measurements with the relative mean variability lowest in the washed and rubbed treatment, highest in the control group and intermediate in the 75° F washed treatment. Coefficients of variation for egg shell permeability were higher in this study than in previous reports when this technique was used *(4, 5)* because the present study necessitated the use of individual eggs rather than paired observations.

[a] Published with the approval of the Director of Research as Paper No. 1149 of the Journal Series.

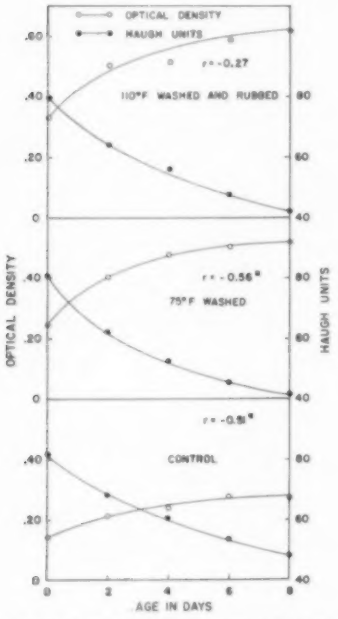

Figure 1. The relationship between egg shell permeability and interior physical quality as measured by Haugh units.[1, 2, 3]

[1] Each observation represents a mean for 32 eggs.
[2] Scores of 79 or higher, 53 to 79 and 30 to 53 represent grades AA, A and B, respectively.
[3] Optical density is directly proportional to permeability.
* $p = <0.05$.

TABLE 1

Mean coefficients of variation for Haugh units and optical density observations from control, 75° F washed, and 110° F washed and rubbed treatments

Observation	Treatment		
	Control	75° F H_2O washed	110° F H_2O washed and rubbed
Haugh units	14.44	18.75	17.59
Optical density	54.51	34.76	31.93

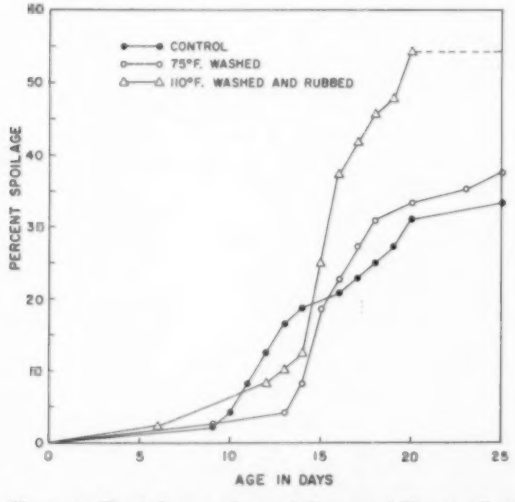

Figure 2. The influence of egg shell permeability as affected by washing on the rate of bacterial spoilage of shell eggs.

The effect of egg shell permeability on bacterial penetration is shown in Figure 2. The rate of spoilage for the three egg shell permeability levels was similar until the 15th day of storage. At this time the rate of spoilage for the 110° F washed and rubbed group sharply increased. Differences were detected in rate of spoilage after 25 days between control and the 110° F washed and rubbed groups. The per cent spoilage in the 75° F washed group was slightly larger than that of the control but was not sufficiently smaller than that of the 110° F washed and rubbed group to test significant at the 5% level.

A significant relationship between egg shell permeability and interior physical quality was demonstrated for 2 levels of permeability (Figure 1). However, when a third and significantly higher level of permeability was used, no relationship was found. This might be attributed to the equalization of shell permeability caused by rubbing the moist egg and was indicated by the relatively low mean coefficient of variation of permeability in rubbed eggs (Table 1). The rubbing action evidently damaged the cuticular layer that is present on the surface of the shell *(5, 9, 12)*. The effect of this physical action would have a tendency to create a similarity in permeability of all eggs regardless of differences that existed before treatment. Therefore, a relationship that might have existed initially between egg shell permeability and interior physical quality probably would be negated by the rubbing action on the moist egg shell. This phenomenon is evidenced between treatments by the relative similarity of the coefficients of variation for Haugh unit scores and on the other hand by the spread in the coefficients of variation for shell permeability (Table 1).

The relationship between egg shell permeability and interior physical quality may be attributed to the rate of carbon dioxide loss from the albumen. Mueller *(11)* employed weight loss as a measurement of shell permeability and found that weight loss and carbon dioxide loss were significantly correlated. Fromm *(4)* demonstrated the relationship between weight loss and shell permeability. Numerous workers have reported that albumen quality and carbon dioxide loss from the egg albumen are related. Hence, it may be assumed that differences in the rate of albumen quality loss probably is related to rate of carbon dioxide loss which in turn is affected by the level of egg shell permeability (Figure 1).

According to the results in Figures 1 and 2, a relationship does exist between egg shell permeability and bacterial entrance into the egg. However, differences in permeability must be relatively large in order to affect a change in rate of bacterial penetration into the egg. The physical factors involved which may influence changes in permeability of the egg shell caused by washing were discussed by Fromm *(5)*. However, physical stress factors such as ambient temperature changes *(5)*, and environmental temperature and humidity *(1, 5, 8)* coupled with washing may provide the sufficient differential in egg shell permeability to facilitate the microbial contamination of eggs.

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SUMMARY

Interior physical quality and bacterial contamination of eggs as influenced by egg shell permeability were investigated. It was found that interior physical quality and rate of bacterial contamination are related to permeability of the egg shell. Reasons possible for these relevancies are discussed.

Acknowledgment

The authors wish to express their appreciation to Mr. Charles W. Haywood, Jr. for laboratory technical assistance and to Mr. and Mrs. R. B. Kelly and Mr. R. B. Kelly, Jr. of the Kelly Poultry Farms, Garner, North Carolina, for their cooperation during this study.

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Effect of Pre-Washing Oranges for Concentrate Prior to Bin Storage

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(Manuscript received January 2, 1960)

IN FROZEN CITRUS CONCENTRATE processing—as in any segment of the food industry—sanitation is important to profitable operation. Thus, sanitation control starts when fruit is received at the canning plant and extends through all subsequent operations. General practice is to unload fruit from trucks onto a conveyor system; pre-grade for maturity and soundness; store in bins; wash; regrade, and sanitize prior to entering the extractors. The efficiency of these operations has a direct bearing on the microbial population of the extracted juice. Of these processes, fruit washing is the most effective in removing soil and microorganisms from fruit surfaces. Customary practice of initially washing fruit after bin storage results in an accumulation of unsightly soil and debris on equipment prior to this operation, and often makes for inefficiency in initial grading due to adherence of soil particles to fruit surfaces. Thus it was thought that washing fruit immediately after unloading would result in cleaner fruit handling operations and cleaner equipment before regular washing, and that it might also improve grading efficiency and reduce fruit surface contamination. However, storing fruit under moist conditions had been said to be more conducive to its physical breakdown.

In order to obtain factual information on this subject, an investigation was made jointly by Minute Maid Corporation and Continental Can Company's Metal Division Research and Development Department to evaluate fruit washing procedures and specifically to study the effect of a pre-wash prior to bin storage on (1) microbial contamination of fruit surfaces; (2) fruit cleanliness; (3) grading efficiency; and (4) physical breakdown of fruit in bins. The purpose of this paper is to report the results of these investigations.

PROCEDURE

Fruit surface studies reported herein were made in accordance with the procedure described by D. I. Murdock *et al (5)*. A slight deviation from the standard rinse test was employed to determine the number of microorganisms on fruit surfaces. In brief, a sample consisted of 10 oranges distributed equally in two sterile 1-gal pails, one of which contained 1000 ml of sterile water. The pail with water and oranges (containing a small amount of wetting agent) was placed on a mechanical shaker for 3 min. The rinse water was then transferred aseptically to the other pail which was shaken for a similar period. Final rinse water was then plated in the usual manner. Orange serum agar was used as the plating medium, and all plates were counted after 48- to 72-hr incubation at 30° C (86° F).

This study, except for the bacteriological phases, covered all fruit processed at one concentrate plant during the Valencia season. The number of microorganisms on fruit surfaces was determined over a 3-week period under fruit handling conditions believed to be typical. Samples were obtained daily from the stations indicated in Figure 1. During the test, the fruit washing procedure was alternated between washing fruit prior to entering the storage bins (called "washed fruit"), and not washing prior to bin storage (called "unwashed fruit"). Each period lasted 3 to 4 days, the time between plant clean-ups. Except for the pre-wash operation immediately after fruit unloading and prior to bin storage, fruit washing procedures for both variables were conventional and remained constant throughout.

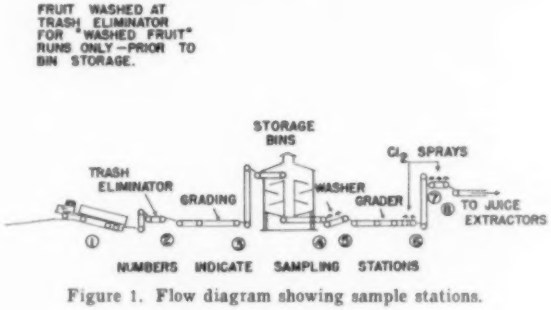

Figure 1. Flow diagram showing sample stations.

The fruit washer located before the bins consisted of a series of fan-type sprays installed over the roller bed of the trash eliminator (between sampling stations 1 and 2). The sprays operated at 90–100 lb pressure and the water contained 4 to 10 ppm of chlorine. After the bins, all fruit was sanitized by means of a brush washer, detergents and germicidal sprays containing chlorine at 20–30 ppm.

Fruit cleanliness evaluations (based on soil removed from oranges by the rinse water in prepara-

tion of the sample for plating) were determined by observing the optical density of rinse water using a Model 401 Lumetron equipped with a 420 mmc filter (measured as per cent light transmission). A control or blank sample of water without oranges was carried through each analysis for plating and light transmission determination. The particle density remaining on a paper filter pad, through which rinse water had been filtered, was also employed as another method of evaluating fruit cleanliness.

Grading efficiency was measured over a seven-week period by comparing fruit culled to total fruit received. Culls removed as the fruit was unloaded ("fruit to bins") were weighed automatically and reported as boxes containing 90 lb each. "Fruit to process" culls were determined by placing an electrically-operated counter on the cull conveyor belt after the final graders. The counter recorded each culled orange as it passed over the device. Culled fruit was converted to boxes by dividing the oranges counted by 200.

RESULTS AND DISCUSSION

Data on fruit surface contamination of washed and unwashed fruit for each handling operation from truck to extractor are presented in Figure 2.

Statistical analysis of the data showed:

1. A pre-wash operation prior to bin storage significantly decreased the bacterial count between stations 1 and 2, at the 5% reliability level. The decrease for unwashed fruit was not significant.
2. The increase in count between stations 2 and 4 was sizable in both procedures; however, there is no statistically significant increase in bacterial count for the washed versus unwashed fruit between stations 2 and 3, or 3 and 4, although the washed fruit at station 4 shows a higher count than unwashed fruit. In other words, an initial wash did not materially reduce the count on the fruit leaving the bins.
3. The washed fruit counts from bins to extractors paralleled those of unwashed fruit, although the pre-washed fruit gave consistently higher counts. However, the higher values were not found to be significant.
4. The variation in counts for washed versus unwashed fruits at stations 5 through 8 was not statistically analyzed but appears to be similar to the data for stations 1 through 4.
5. It was observed during the study that no physical breakdown or mold growth occurred on fruit which had been washed and stored in bins for periods up to 48 hr. In addition, the bins remained cleaner during the storage period.

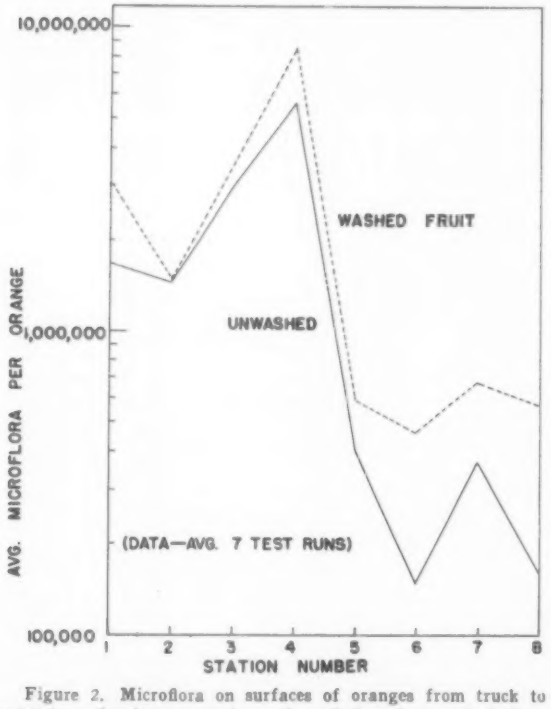

Figure 2. Microflora on surfaces of oranges from truck to extractors showing comparison of washed and unwashed fruit prior to bin storage.

Results obtained in evaluating fruit for degree of cleanliness, by the two methods previously described, are illustrated in Figures 3 and 4. Figure 3 is a photograph of pads after filtering rinse water from each station during one sampling. Visual observation showed that the unwashed fruit carried a heavier load of soil up through station 4. Commencing with station 5, soil load was about equal between the two processes remaining fairly constant up to the point of extraction.

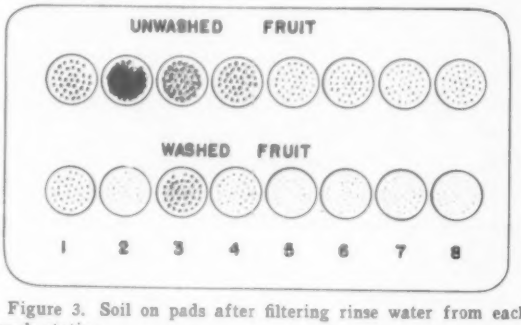

Figure 3. Soil on pads after filtering rinse water from each sample station.

Light transmission values obtained by observing the optical density of rinse water are presented graphically in Figure 4. Data for washed and unwashed fruit represent the average of 7 test runs. The higher transmission values indicate less opacity and, thus, less soil rinsed from the sample of oranges. Oranges sampled from the truck, whether subsequently washed or unwashed, showed almost identical Lumetron readings, establishing that fruit used for the two processes was equal in initial soil load. These results also show the pre-washed fruit to be markedly cleaner than un-

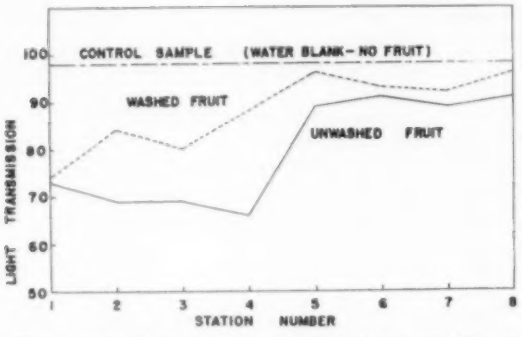

Figure 4. Light transmission values of rinse water from each sample station showing comparison of washed and unwashed fruit prior to bin storage.

washed fruit up to the brush washer (station 5), but only slightly cleaner from this point to the extractors.

In checking the efficiency of the first grading operation, it was noted that more boxes of fruit were culled when unwashed fruit entered the bins (Table 1). One

TABLE 1

Fruit culled by graders
(Washed versus unwashed fruit)

	Unwashed			Washed		
	Total		Per cent culled	Total		Per cent culled
	Boxes received	Boxes culled		Boxes received	Boxes culled	
Fruit to bins	199,031	982	0.493	201,142	749	0.372
Fruit to process	198,049	956	0.483	200,393	1,028	0.513

assumption might be that the graders discarded more sound oranges when fruit was dirty than when it was clean. As a matter of interest, initial graders stated it was much easier to grade washed rather than unwashed fruit. Data accumulated from final grading (fruit to process) showed no significant difference in number of boxes culled between washed and unwashed fruit. In the course of this investigation, it was observed that electrically recording the number of culls after the final grading operation provided an excellent method of checking grading efficiency. In this particular study a record was kept of the culls graded by each shift. It was noted that when the initial graders "fell down on the job," the final graders culled more fruit. Also, in one instance when the percentage of culls graded was exceptionally high it was found that the final graders were overgrading. Keeping a record of these culls also gives a more accurate basis for figuring yields at the plant.

SUMMARY

Although oranges washed prior to bin storage, in addition to regular sanitizing after bin storage, showed a decrease in surface contamination immediately after the initial wash operation, the over-all effect of pre-washing was not statistically significant. However, fruit handling equipment and particularly the storage bins, remained in a more sanitary condition; and the washed fruit was cleaner from the standpoint of surface soil up to the point of final brush washing. No physical breakdown of fruit occurred. Graders preferred handling washed fruit and culled more oranges entering bins when they were unwashed. Final graders culled from each process equally.

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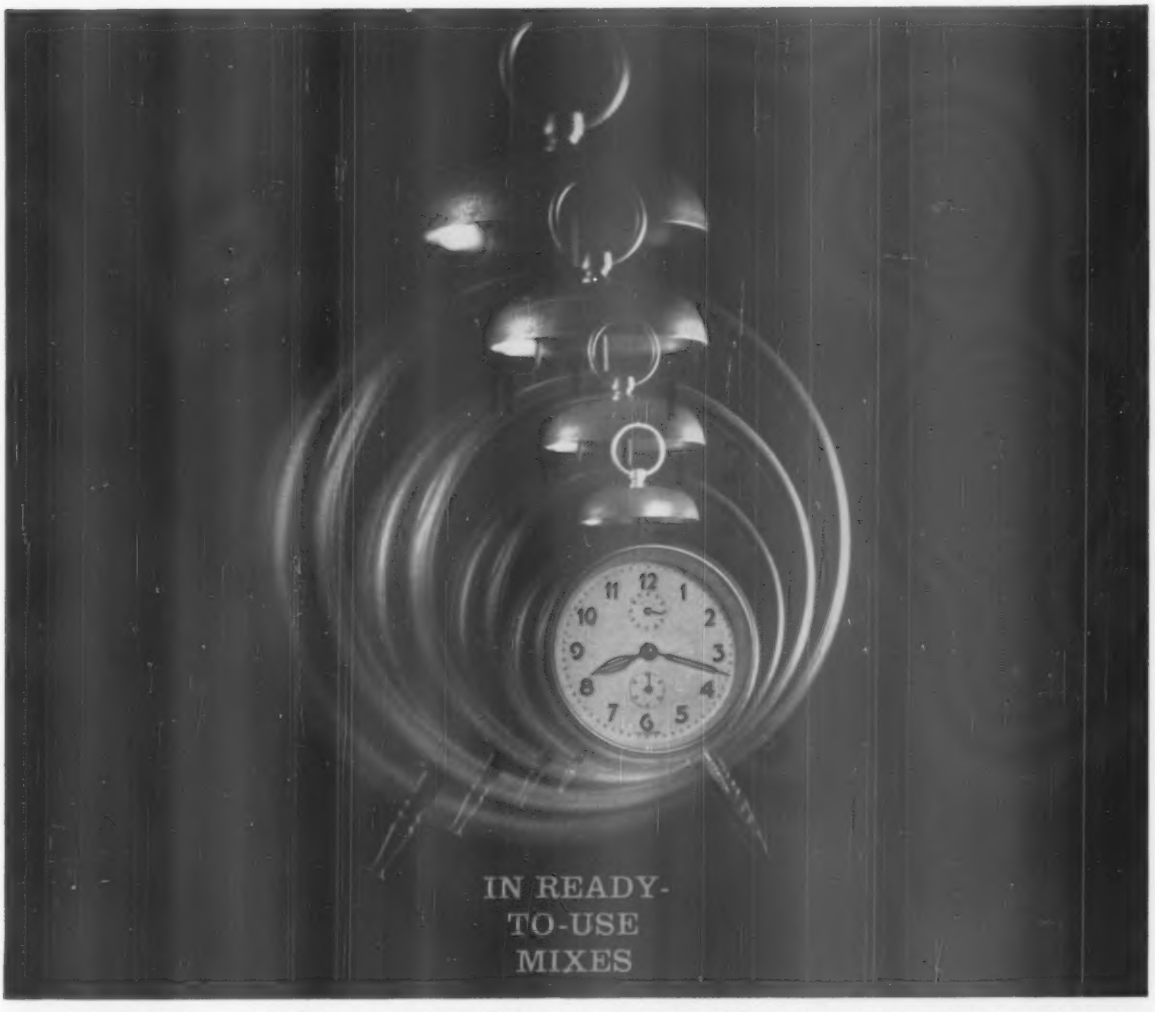

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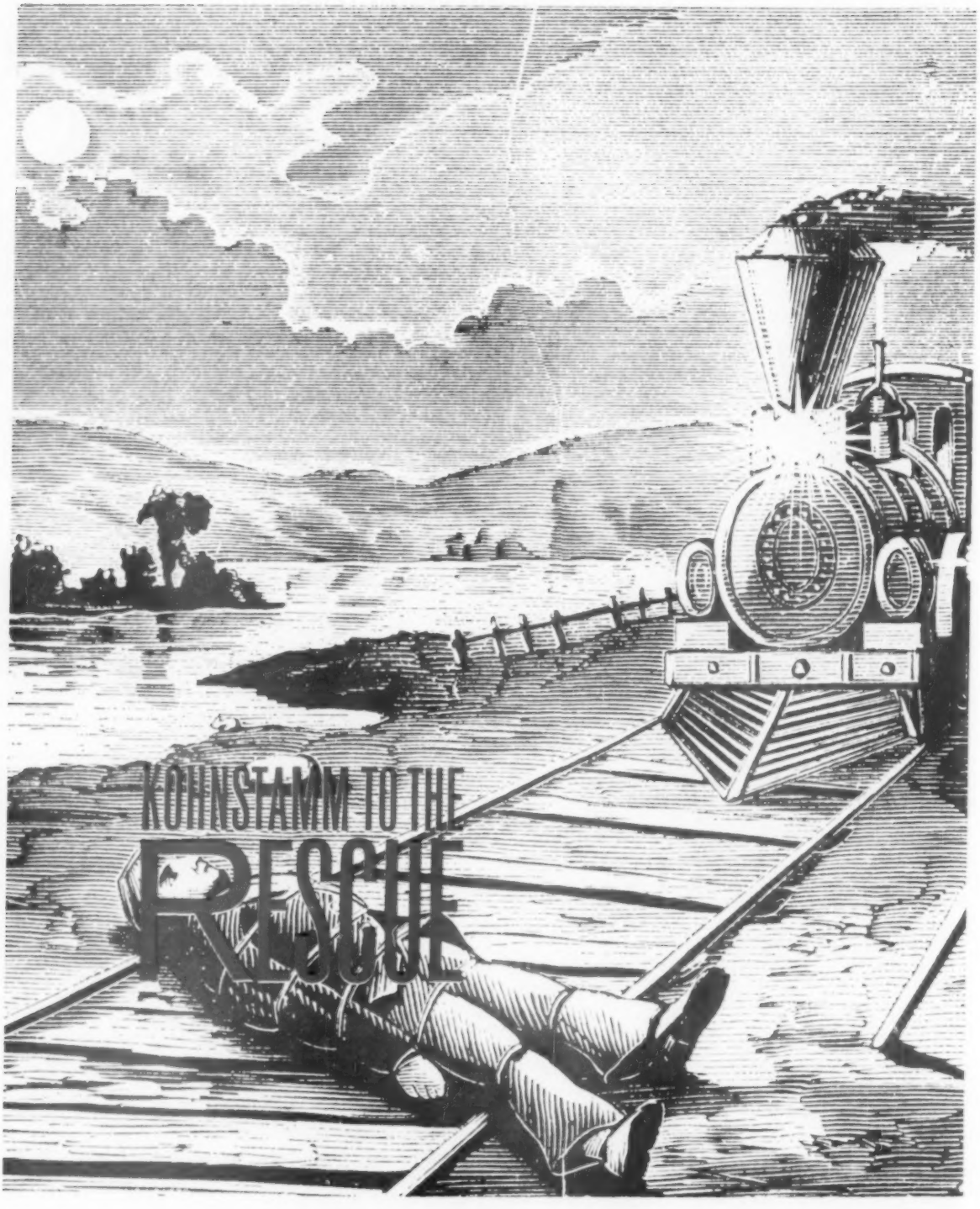

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A Study of the Growth of *Aspergillus oryzae* In Irradiated Components of Foods[a]

(Manuscript received March 29, 1960)

M. L. Fields,[b] G. R. Ammerman,[c] and N. W. Desrosier[d]

In studying the effect of cathode rays on maturation changes in tomato fruits, Burns *(2)* found that irradiated tomato fruits inoculated with *Erwinia aroidae* exhibited a more rapid rate of decay after a dose of 1 x 10^6 rads as compared to inoculated controls. Nehemias *et al (7)* in 1954 reported that peaches and cherries packaged in polyethylene bags underwent a more rapid rate of spoilage after irradiation. These workers hypothesized that radiation caused either physical or chemical change in the fruit, enabling mold to grow more readily. In fact, their data indicated a stimulation of growth at lower doses than 1 x 10^6 rads.

Hooker and Duncan *(4)* have shown that potatoes inoculated with the causal agent of fusarium dry rot and bacterial soft rot decayed quicker than the inoculated controls. Their data showed that, as the radiation dose was increased to 135 kilorep, the average rate of growth was between 3 and 4 times more rapid than in the non-irradiated tissue. Beraha *et al (1)* observed that potatoes which were inoculated with *Pythium debaryanum* showed increased susceptibility to decay by this organism after irradiation when compared to the non-irradiated controls.

Burns *(2)* suggested that the reason why the irradiated tomatoes rotted more than the controls might be due to the action of the irradiation upon tissue breakdown due to depolymerization of pectin found in the middle lamella. Burns *(2)* showed that depolymerization occurred in his studies in which pure solutions of pectin were irradiated. Roberts and Procter *(9)* have shown that the middle lamella of potato tuber tissue was altered by doses of 1000 kilorep and above. Hooker and Duncan *(4)* have also advanced the theory that the weakening of the plant tissue may increase the susceptability of potatoes to spoilage.

In order to test the hypothesis that microbial decay might be accelerated at dosages which have been applied to foods, the following study was instituted. Starch and gelatin were selected as representing higher molecular compounds which are common in foods while glucose and asparagine were selected as lower molecular compounds. These selected components of foods were irradiated separately and recombined with other components to give a complete growth medium. The effect of irradiation upon the food components was measured by the amount of growth developed by *Aspergillus oryzae*.

MATERIALS AND METHODS

Radiation facility. The food components were irradiated in a glass chamber with aluminum windows one mil in thickness. The cell was 2 cm thick and 3.8 cm in diameter. The irradiation chamber was held in a fixed position 6 in from the end of the accelerator by a clamp device bolted to the end of the accelerator. The linear electron accelerator built to operate between 2.0 and 6.0 Mev, was controlled at 5.6 Mev. Ten per cent of the electrons in the unscanned cathode beam were lower in energy than 5.6 Mev *(6)*. Dosimetry was performed using the ceric sulfate method *(10)*.

Preparation of spore suspension. *Aspergillus oryzae* (Ahlburg) Cohn ATCC strain 11601 was obtained from the American Type Culture Collection, Washington, D. C. This organism was grown in Roux flasks at room temperature, and the spores were harvested in about a week after spore production was observed. The spores were removed from the surface of the agar by moving a sterile glass rod over the surface which had been flooded with sterile, distilled water. A glass column filled with glass wool and attached to a suction flask was used to filter the spore suspension gently. Following filtration, the spore suspension was transferred to a sterile Erlenmeyer flask containing glass beads, and the suspension was agitated thoroughly to break up spore clumps.

Growth media. The growth media in which the irradiated glucose and/or starch were used contained the following constituents: KNO_3, 2.0 g/l; NaCl, 0.4 g/l; $MgSO_4 \cdot 7H_2O$, 0.4g/l; $FeSO_4 \cdot 7H_2O$, 10 mg/l; and KH_2PO_4, 2.0 g/l. The glucose was irradiated in a solution containing 90 g per liter. The starch solution contained 50 g per liter. Both solutions were autoclaved prior to irradiation (15 lb of steam for 15 min). The irradiated glucose solution was added to the above sterile salt solution to yield a growth medium containing 30 g of glucose per liter. The irradiated starch was added to the sterile salt solution to yield 16 g of starch per liter.

Growth media in which irradiated gelatin was used contained the following constituents: gelatin (irradiated or control), 2.0 g/l; glucose, 30.0 g/l; $MgSO_4 \cdot 7H_2O$, 0.25 g/l; and KH_2PO_4, 1.5 g/l.

A nutritionally incomplete growth medium (lacking minerals) which consisted of 90 g/l of glucose (Bacto-Dextrose) and 6 g/l of asparagine (Bacto-Asparagine) was autoclaved (15 lb of steam for 15 min) prior to irradiation. After irradiation, 5 ml of the glucose-asparagine solution were added to 10 ml of sterile distilled water in the growth flask. The resulting growth medium contained 2 g/l asparagine and 30 g/l of glucose.

A 4% solution of Bacto gelatin was irradiated at the following doses: 8.72 x 10^4, 26.16 x 10^4, 43.6 x 10^4, 61.04 x 10^4, 130.8 x 10^4, 218 x 10^4 and 392 x 10^4 rads. The solutions irradiated at 130.8 x 10^4, 218 x 10^4 and 392.4 x 10^4 rads formed a gel which resisted boiling water temperature. For this reason, the gelatin which had been irradiated at doses of 8.72 x 10^4, 26.16 x 10^4, 43.6 x 10^4 and 61.04 x 10^4 rads was used in the growth studies.

A. oryzae was cultured in 250 ml Erlenmeyer flasks. Fifteen ml of each growth medium were used except when gelatin was used as the only nitrogen source. In this experiment, 20 ml of the liquid broth per flask were used as the growth medium. Inoculations were accomplished by pipetting aseptically 1 ml of a spore suspension of *A. oryzae* into the growth flask within 2 hr after irradiation. The cultures were incubated at 30° C ± 1° C for one week.

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[b] Food Processing Laboratories, Horticulture Department, University of Missouri, Columbia, Missouri.

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[d] Professor of Food Technology, Purdue University, Lafayette, Indiana.

The mycelial mat was separated from the broth by filtering on previously weighed Whatman No. 2 filter paper. The filter paper, and the mycelial mat, were placed in one half of a Petri plate and dried to constant weight. The time required to reach constant weight was usually 15–17 hr at 70° C. Weights were recorded in mg.

RESULTS AND DISCUSSION

The growth of *A. oryzae* on glucose-asparagine which had received a dose of 43.5 x 10^4 rads was significantly higher than the growth on the non-irradiated control. Also, the growth at 8.72 x 10^4 rads was approaching significance. The same stimulation was observed when the organism was grown on irradiated glucose. The growth on media irradiated at 43.5 x 10^4 rads was significantly higher than the control. This significant stimulation was also produced at dosages of 130 x 10^4 and 218 x 10^4 rads. These data are shown in Tables 1 and 2.

Growth responses on irradiated starch are shown in Table 3. When irradiated starch was used as the sole carbon source, there was no stimulation although the growth at a dose of 8.72 x 10^4 rads approached significance when compared with the control. At the level of 392 x 10^4 rads there was a significant decline in growth when compared with the control. Growth on starch which received a dose of 8.72 x 10^4 rads was significantly higher than the growth on media treated at 87.2 x 10^4 rads and 392.0 x 10^4 rads. The growth on starch which was irradiated at 305.0 x 10^4, 218.0 x 10^4 and 43.5 x 10^4 rads was significantly higher than the growth on starch irradiated at 392.0 x 10^4 rads.

When irradiated gelatin was used as the sole source of nitrogen in the growth medium, there was no significant difference between the non-irradiated controls and the irradiated treatments.

TABLE 1

Yield of mycelia of A. oryzae when grown in irradiated glucose-asparagine medium. Weights in milligrams

		To compare for significance between treatments, take yield at left minus yield below*							
		Dosage in rads x 10^4 and mean mycelium yield							
Dosage in rads x 10^4	Mean yield of mycelium	Control	218	305	392	130	87.2	8.72	43.5
		10	19	20	22	23	26	30	44
43.5	44	34*	25*	24*	22	21	18	14	....
8.72	30	20	11	10	8	7	4	....	
87.2	26	16	7	6	4	3	....		
130.0	23	13	4	3	1	....			
392.0	22	12	3	2	....				
305.0	20	10	1	....					
218.0	19	9	....						
Control	10	....							

* Significant at the 5% level by the Duncan (1955) test.

TABLE 2

Yield of mycelia of A. oryzae when grown in a medium containing irradiated glucose as the carbon source. Weights in milligrams

		To compare for significance between treatments, take yield at left minus yield below*							
		Dosage in rads x 10^4 and mean mycelium yield							
Dosage in rads x 10^4	Mean yield of mycelium	Control	8.72	392.0	87.2	305.0	218	130.0	43.5
		78	87	89	99	105	110	110	110
43.5	110	32*	23	21	11	5	....	....	....
130.0	110	32*	23	21	11	5	....		
218	110	32*	23	21	11	5	....		
305.0	105	27	18	16	6	....			
87.2	99	21	12	10	....				
392.0	89	11	2	....					
8.72	87	9	....						
Control	78	....							

* Significant at the 5% level by the Duncan (1955) test.

TABLE 3

Yield of mycelia of A. oryzae when grown in a medium containing irradiated starch as the carbon source. Weights in milligrams

		To compare for significance between treatments, take yield at left minus yield below*							
		Dosage in rads x 10^4 and mean mycelium yield							
Dosage in rads x 10^4	Mean yield of mycelium	392.0	87.0	130.0	305.0	Control	218.0	43.5	8.72
		85	91	96	97	97	98	99	104
8.72	104	19*	13*	8	7	7	6	5	....
43.5	99	14*	8	3	2	2	1	....	
218.0	98	13*	7	2	1	1	....		
Control	97	12*	6	1	....				
305.0	97	12*	6	1	....				
130.0	96	11	5	....					
87.0	91	6	....						
392.0	85	....							

* Significant at the 5% level by the Duncan (1955) test.

An explanation of the stimulated growth may be that combined carbohydrates sometimes give stimulation of growth in fungi. Lilly and Barnett *(5)* have discussed the importance of mixed carbon sources upon fungal growth. These workers indicate that the effect of mixed carbon sources is highly specific. Phillips *(8)* indicated in his studies that irradiation produced organic acids from glucose. The production of such acids might account for the stimulation observed in this experiment.

Under the experimental condition of this study the data support the hypothesis that microbial growth on irradiated foods may be stimulated. The observations of this study are in agreement with Burns *(2)*, Nehemias *(7)* and Hooker and Duncan *(4)* in this respect. Since the observations of Nehemias were made on packaged fruit, the findings are applicable to packaged as well as non-packaged foods.

The significance of studies involving microbial growth on food constituents are not only important in helping to elucidate the growth of micro-organisms on irradiated foods, but also on the possibility of using ionizing radiation as a means of preparing better media upon which to grow fungi from poorer nutritional sources.

SUMMARY

The growth of *Aspergillus oryzae* was found to be significantly higher on irradiated glucose-asparagine and glucose when these materials were used in growth media. Although gross physical changes were observed in the irradiated gelatin which was used as the sole source of nitrogen in a growth medium, there was no significant difference in the growth response of the treatments. Inhibition of growth at highest dosage level (392 x 10^4 rads) was observed when *A. oryzae* was grown on irradiated starch.

Acknowledgment

The authors wish to express their thanks to Dr. J. W. MacKay of the Purdue Physics Department for his assistance with the Purdue linear accelerator.

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Notes and Letters

The Invention of Canning: A Direct Translation from the Russian [a, b]

"In the journal *Tekhnika Molodezhi* (No. 2, 1948) appeared a short article containing the information that the contemporary method of food preservation by canning was discovered about 140 years ago by the famous Russian scientist, Vasilii Nazar'evich Karazin.

"Unfortunately, information concerning this inventor and his works is very limited in our literature. The search for more material was without much success.

"In the Leningrad Library, Marxism-Leninism Section, we asked the librarian to give us any available literature about V. N. Karazin. By a lucky coincidence, the librarian turned out to be Karazin's granddaughter. According to her, all archives relating to him were destroyed by a fire. However, later on, we succeeded in getting some material about this inventor of canned meats.

"Vasilii Nazar'evich Karazin was born on January 30, 1773, and died on November 4, 1842. He was interested in many fields of science, was one of the founders of the University of Kharkov, and spent much time studying the technology of various food products.

"We succeeded in finding in the Leningrad Public Library the following publication by Karazin, issued in Moscow in 1829, entitled, 'Concerning the Most Suitable Method for Preserving and for Long Distance Shipping of Nutritious and Kitchen Ready Products of the Animal and Plant Kingdoms.' In this monograph the Russian scientist describes the original method for processing of canned meat products.

"According to his account of the experiment, three boxes of canned meats were prepared and then shipped to a vessel which just happened to be leaving for a tour around the world. After three years the boat returned to Petrograd and the canned meats were delivered to Khurkov. During a meeting of a philotechnical society, of which V. N. Karazin was the president, a few cans were opened and the meat immersed in boiling water. The meats were then tested organoleptically. The participants in the test judged the canned meat, after three years' storage, to compare favorably in organoleptic qualities with fresh meat stored frozen.

"The following statement was written by Vasilii Nazar'evich about his invention: 'The first presentation of this invention to the government was made by me in 1806. Consequently, it was made much earlier than the similar presentations and descriptions of the method made in foreign countries.'

"Thus, a Russian scientist was the first man in the world to develop and present a method for the canning preservation of meat products; he was also the man who first investigated the quality of the canned meats.

"The philotechnical society greatly praised this invention. However, the Tsarist Government did not support this talented inventor and made it difficult for him to bring his invention into production. This was because V. N. Karazin was on the list of 'red ones.' As the author of 'Meat Preservation by Canning,' he was forgotten. In the meantime there appeared a new 'inventor'—the Frenchman Appert—to whom credit is given for the invention of the meat canning process. However, the fact is that Appert presented his disclosures of the process at a much later date than did the Russian scientist.

"In these same years, V. N. Karazin developed the technology of processing dry bouillon, canned fruits, and absolute alcohol. Russian armies, in defeating Napoleon's army outside Russia, experienced difficulties in food supply. Thanks to the food products processed by the formula of V. N. Karazin, the food supply to the armies greatly improved.

"The Science Committee in a report to the Ministry of War expressed a great appreciation to V. N. Karazin for his help in improving the food supply of Russian armies abroad (reference: *Syny otechestva*, i.e., *The Son of the Fatherland*, No. 32, 1815).

"In the way described, we succeeded in establishing that the inventor of meat preservation by canning, was the Russian scientist, Vasilii Nazar'evich Karazin." Karazin."

[a] A direct translation of an article entitled "Originator of Our Country's Meat Canning Process" by M. Gonchurov, printed in *Myasnaya Ind. S.S.S.R. 29*, No. 2, 29–30 (1958) (Meat Ind. of the U.S.S.R.).

[b] Translated from the original by Dr. Eugen Wierbicki, Rath Packing Co., Waterloo, Iowa.

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410B

Irradiation Preservation of Pacific Northwest Fish: Precooked Fish Sticks

In a study to determine the storage life of precooked breaded fish sticks irradiated at various doses up to 2.0 megarads, two temperatures —room temperature and 35° F—were chosen. For room temperature storage, the fish sticks were packed in hermetically sealed cans and irradiated at 1.0 and 2.0 megarads. For 35° F storage, the fish sticks were packed either in mylar-polyethylene pouches or in hermetically sealed cans and irradiated at 0.25, 0.5, 1.0, and 2.0 megarads. These doses are well below the generally accepted sterilization level of 4.8 megarads.

The storage characteristics at room temperature of the 1.0- and 2.0-megarad fish sticks were poor. The storage life at 35° F of the irradiated fish sticks packed in cans was about 8 to 12 weeks, but the irradiated fish sticks were only fair in organoleptic quality throughout most of their storage life because a musty odor developed and the white meat darkened.

The storage life at 35° F of fish sticks irradiated at 0.5, 1.0, and 2.0 megarads appeared to be equal for those packed in mylar-polyethylene pouches and those packed in hermetically sealed cans. The storage life of the 0- and 0.25-megarad samples was less for those packed in mylar-polyethylene pouches than for those packed in cans.

The bacteriological history of fish sticks packed in the mylar-polyethylene pouches and stored at 35° F is shown in Table 1; that of fish sticks packed in No. 2 cans and stored at 35° F is presented in Table 2.

The results of this study, though negative, are worthy of record since they indicate the limitations of low level irradiation of precooked fish sticks.

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TABLE 1

Bacteria counts on irradiated precooked breaded fish sticks packed in mylar-polyethylene pouch and stored at 35° F

Time of storage	0 megarad		0.25 megarad		1.0 megarad		2.0 megarad	
	Aerobic	Anaerobic	Aerobic	Anaerobic	Aerobic	Anaerobic	Aerobic	Anaerobic
Weeks	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*
0	250	20	30	30	<10	<10	<10	<10
2	31,000	4,000	....	....	30	<10	<10	<10
6	1,000	1,000	....	....	<10	<10	<10	<10
8	28,,000	13,000	1,000	1,000	....	....	....	....
10	670,000	24,000	170,000	9,000	<10	<10	<10	<10
14	920,000	12,000	3,000	1,000	<10	<10	<10	<10

TABLE 2

Bacteria counts on irradiated precooked breaded fish sticks packed in No. 2 cans and stored at 35° F

Time of storage	0.25 megarad		0.5 megarad		1.0 megarad		2.0 megarad	
	Aerobic	Anaerobic	Aerobic	Anaerobic	Aerobic	Anaerobic	Aerobic	Anaerobic
Weeks	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*	*Bacteria/g*
0	6.8×10^8	2×10^6	250	20	<10	<10	<10	<10
4	1.6×10^8	....[1]	1.4×10^8	....[1]	<10	....[1]	<10	....[1]
6	....	....	1,000	1,000	....	....	....	....
8	....	....	400	300	<10	<10	<10	<10
12	....	....	16,000	1,000	130	<10	20	<10
16	....	....	....	....	<10	<10	<10	<10

[1] Samples lost by error.

Nitrogen Content of Pork Adipose Tissue Proteinaceous Fraction

It is generally accepted as a working premise that animal tissue proteins contain 16% nitrogen. In the AOAC *Methods of Analysis (1)* the multiplication of Kjeldahl nitrogen by 6.25 to obtain meat product and by-product protein is recommended. Exception is made for gelatin, which is recognized to contain 18% nitrogen *(2)*. Most analysts using the 6.25 factor realize that it is an average. The purpose of this paper is to demonstrate the actual nitrogen content of pork adipose tissue proteinaceous fraction.

Procedure. Several hundred analyses of residue from pork fat rendering were performed in our laboratory in the following way:

a. Moisture was determined by the air oven method *(3)*.

b. Fat was determined by Soxhlet extraction *(5)* of the residue from moisture determination.

c. Proteinaceous residue was determined by weighing the contents of Soxhlet thimble.

d. Nitrogen was determined on the whole material by the Kjeldahl method *(1)*. Protein was obtained by multiplying nitrogen by 6.25.

e. Ash was determined in muffle furnace *(4)*.

f. In some cases protein was determined on proteinaceous residue.

A few typical results obtained in these analyses are shown in Table 1. Totals of fat, moisture, ash and protein were always more than 100%. Furthermore, protein was 1 to 2% higher than proteinaceous residue—which was doubly surprising since the proteinaceous residue contained ash minerals.

TABLE 1

Selected typical analysis of rendered pork adipose tissue. Components in per cent of wet weight

Protein		Ash	Moisture	Fat	Proteinaceous residue
N × 5.85	N × 6.25				
76.4	81.6	2.0	3.7	16.8	79.5
78.0	83.3	2.1	4.8	15.3	79.9
76.7	81.9	2.7	3.7	17.1	79.2
79.2	84.6	3.3	6.3	12.8	80.9
77.8	83.1	2.3	4.7	14.9	80.4

The above observations led us to believe that the assumption that proteinaceous fraction contained 16% nitrogen did not reflect the true picture.

Nitrogen content of the protein material was recalculated from Kjeldahl nitrogen and proteinaceous residue minus ash values. Any glycogen content of the tissue was disregarded. According to Wertheimer *et al (6)* adipose tissue of healthy animals does not contain any glycogen. Experiments where protein was determined both on whole material and proteinaceous residue showed that no significant loss of nitrogen occurs during Soxhlet extraction. Nitrogen content of the proteinaceous residue equaled the nitrogen content of the whole material.

CONCLUSION

Data compiled from 150 analyses showed an average 17.1% nitrogen in proteinaceous material. This value varied plus or minus 0.3%. Thus, the average factor by which Kjeldahl nitrogen should be multiplied to estimate protein content became 5.85. This evidence seems to indicate that most of pork adipose tissue proteins are of a gelatin or collagen type, as their nitrogen content approaches the nitrogen content of gelatin.

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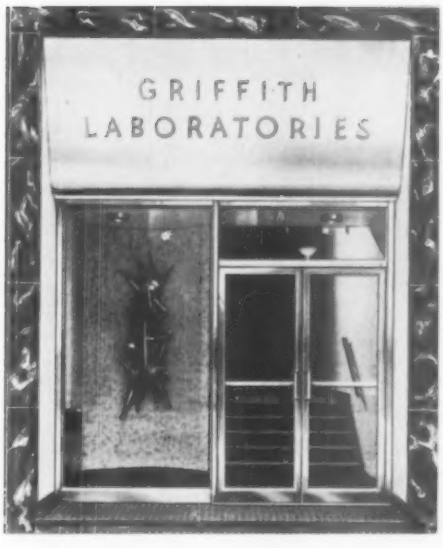

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(Continued from page 18 preceding technical section)

to an average of 580 days at 41° F) limited cooking tests and other observations indicated a gradual reduction in quality was taking place. (See page 395).

Quality *Market eggs*

Interior physical quality and bacterial contamination of market eggs as influenced by egg shell permeability. Daniel Fromm and Robert J. Monroe.

Interior physical quality and bacterial contamination of eggs as influenced by egg shell permeability was investigated. It was found that interior physical quality and rate of bacterial contamination are related to permeability of the egg shell. Reasons for these relevancies are discussed. (See page 401).

Radiation preservation *Growth of A. oryzae as measure of radiation effect*

A study of the growth of Aspergillus oryzae in irradiated components of foods. M. L. Fields, G. R. Ammerman, and N. W. Desrosier.

Growth of *Aspergillus oryzae* was found to be significantly higher on irradiated glucose-asparagine and glucose when these materials were used in growth media. Although gross physical changes were observed in irradiated gelatin used as the sole source of nitrogen in a growth medium, there was no significant difference in the growth response of the treatments. Inhibition of growth at highest dosage level (392×10^4 rads) was observed when *A. oryzae* was grown on irradiated starch. (See page 407).

Industrial history *Russian research on the invention of canning*

The invention of canning, a direct translation from the Russian.

The Russian scientist, Vasilii Nazar'evich Karazin, is declared to be the inventor of meat preservation by canning. (See page 410).

Radiation preservation *Pacific cod*

Irradiation preservation of Pacific Northwest fish. I. Cod fillets. David T. Miyauchi.

The specific objective of this study was to determine the effect of varying doses of ionizing radiation on the palatability and storage characteristics of raw fillets of Pacific cod *(Gadus macrocephalus)* held at refrigeration temperatures above freezing. Pacific cod fillets were irradiated at various dosage levels from 0 to 1.86 megarads to determine their initial acceptability and storage characteristics at refrigerated temperatures (32° to 35° F). The optimum irradiation dose for cod fillets appeared to be 0.46 megarad or lower. Irradiation at these low dosage levels increased the storage life of cod fillets at 32° to 35° F by about three times. The objective freshness tests investigated, including determinations for total volatile base, total volatile acid, trimethylamine, and plate counts, did not appear to be a reliable index of quality. (See page 411).

Protein measurement *Actual nitrogen content of pork adipose tissue*

Nitrogen content of pork adipose tissue: proteinaceous fraction. H. E. Wistreich, E. Karmas, and J. E. Thompson.

Evidence indicates that most of the pork adipose tissue proteins are of a gelatin or collagen type as their nitrogen content approaches that of gelatin. Data compiled from 150 analyses showed an average of 17.1% nitrogen in proteinaceous material of pork adipose tissue. (See page 412).

Industry to Assist IFT Sections

Over twenty-five companies associated with the food industry are offering some of their technical personnel as speakers at IFT Section Meetings within the continental limits of the United States.

These companies, including Beckman Instruments, Corn Industry Research Foundation, Diamond Crystal Salt, Hercules Powder Company, H. Kohnstamm & Co., Inc., Reynolds Metals Company, and the Sugar Research Foundation, Inc., in replies to a letter from IFT Headquarters, have listed over sixty individuals, including some Institute Members, who will be available throughout the United States to make technical presentations.

A few subjects listed include packaging materials, applications of instruments to the food industry, nuclear gaging control systems for process control, enzyme production and applications, cleaning systems, uses of chemical food preservatives, antioxidants, flavors, and stabilizers.

At this time, each Section Chairman and Section Secretary has a composite list of the above information for use in acquiring qualified speakers. As additional replies are received, supplemental lists will be forwarded to the Sections.

IFT Elects Three to Executive Committee

Final ballot count of July 18th reveals that C. A. Greenleaf, Maryland Section, John H. Kilbuck, Northern California, and Herbert E. Robinson, Chicago, are new members of the Executive Committee of the Council for two year terms. Other nominees were: Clarence W. DuBois, Robert P. Joslin, and Louis B. Rockland.

Membership of the 1960–61 Executive Committee will consist of the newly elected named above, and Edward E. Burns, Texas, Leslie F. Rutledge, Indiana, Oscar Skovholt, New York, President Hutchings, Past President Wakefield, President-Elect Schultz, and Treasurer Prater.

Literature

ABSTRACTS

General Foods Research Center
Selected by H. A. Campbell

ANALYTICAL METHODS

Theoretical plates in gas chromatography. Effect of distribution ratio, viscosity, and amount of liquid phase.

DUFFIELD, J. J. AND ROGERS, L. B. (Massachusetts Inst. of Technol., Cambridge). *Anal. Chem. 32*, 340–3 (1960).

The value of the mass-transfer term in the van Deemter, Zuiderweg, and Klinkenberg equation increases with the viscosity and volume of the liquid phase. For distribution ratios greater than unity, the term is larger for the smaller ratios. With an increase in the mass-transfer term, lower efficiencies are observed and adjustment of the flow rate for optimum conditions is critical. The optimum flow rate for inefficient columns is generally slow; hence long times are necessary for analysis. Very small samples of vapor rather than liquid were used successfully and required no extrapolation to zero size.

Colorimetric reactions of unsaturated fatty acids with metal salts.

RHODES, D. N. (Low Temp. Research Sta., Cambridge, Engl.). *J. Appl. Chem. 10*, 122–4 (1960).

Esters and glycerides of oleic, linoleic and linolenic acids give colored products having characteristic absorption spectra when treated with ferric chloride or mercuric acetate in the presence of glacial acetic acid and concd. H_2SO_4. These reactions provide the basis of a simple colorimetric method for the detn. of these acids in some fats and oils.

BIOLOGICAL SCIENCES

Biochemistry

Radioimmunoelectrophoresis.

REJNEK, J. AND BEDNARIK, T. (Inst. of Hematology and Blood Transfusion, Prague, Czechoslovakia). *Clin. Chim. Acta 5*, 250–8 (1960).

A simple and sensitive method for the investigation of the fate of proteins in complicated protein systems has been developed. The method combines the advantages of 2 previous methods, immunoelectrophoresis and isotopic labelling of compds. The method is highly sensitive, a number of protein fractions can be identified, and proteins of varied origin can be differentiated, hence this method can contribute to the solution of problems concerned with protein metabolism.

Correlation of amino acid composition with nutritive value of proteins.

BENDER, A. E. (Bovril Ltd., London). *Clin. Chim. Acta 5*, 1–5 (1960).

The nutritive value of a protein can be predicted by comparing its amino acid compn. with the target figures. An improved relationship between chem. score (C.S.) and biological value (B.V.) has been obtained by using new target values measuring the B.V. of a range of amino acid mixts. For B.V.'s between 40 and 100 (which includes most foods) C.S. is numerically equal to B.V. For B.V.'s below 30 the straight line curves in a manner depending on the limiting amino acid. Mixtures lacking only lysine, (i.e. C.S. zero) have B.V. 30; those lacking histidine, leucine + isoleucine, tryptophan or phenylalanine, B.V. 20; those lacking threonine or cystine + methionine, B.V. zero.

Active and inactive modifications of trypsin induced by acetylation.

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WONG, R. C. AND LIENER, I. E. (Univ. of Minnesota, St. Paul). *Biochim. et Biophys. Acta 38*, 80–7 (1960).

The acetylation of trypsin with acetic anhydride results in a heterogeneous mixt. of acetylated derivs. That fraction which is most fully acetylated (85–90%) is enzymically inactive, whereas the partially acetylated (about 50%) fraction is fully as active as unmodified trypsin. These 2 forms of trypsin may be further differentiated on the basis of their soly. properties, chromatographic behavior on DEAE-cellulose, and optical rotation.

Responses of two strains of rats to rapeseed oil and corn oil.

BEARE, J. L., MURRAY, T. K. AND CAMPBELL, J. A. (Dept. of Natl. Health & Welfare, Ottawa, Can.). *Can. J. Biochem. Physiol. 38*, 187–92 (1960).

Apparent coeffs. of digestibility were significantly lower for rapeseed oil than for corn oil in the Sprague-Dawley, but not in the Wistar rats. After 6 weeks the adrenals of Sprague-Dawley rats were larger in the animals fed rapeseed oil than in those fed corn oil, while the adrenals of Wistar rats were not influenced by the dietary oil. These strain differences explain some discrepancies appearing in the literature concerning the effects of rapeseed oil in the rat. There was no significant effect of the strain of rat or the type of dietary oil on the liver storage of vitamin A.

Inhibition of cholesterol biosynthesis by a mitochrondrial extract.

MIGICOVSKY, B. B. *Can. J. Biochem. Physiol. 38*, 339–46 (1960).

Cholesterol biosynthesis was effectively inhibited by an ext. of mitochondria disrupted with sonic oscillations. The inhibitory effect occurred both in vivo and in vitro. The inhibitor substance was heat-labile, and could be prepd. from mitochondria from livers of normal or starved rats. The inhibition appeared to be of the competitive type. The locus of the inhibition in the chain of reactions from acetate to cholesterol appeared to be between acetoacetate and mevalonate. It is suggested that the inhibitor substance present in the mitochondria represents, in part, the homeostatic mechanism that controls cholesterol synthesis by the liver.

Lipid bound glutamic acid deficiency in aging arteriosclerotic subjects.

HAMILTON, R. E. AND PILGERAM, L. O. (Univ. of Minnesota, Minneapolis). *Proc. Soc. Exptl. Biol. Med. 103*, 574–7 (1960).

A ninhydrin pos., lipid bound factor chromatographically identified as glutamic acid has been found in the org. solvent ext. of human plasma α and β lipoproteins. This factor is grossly deficient ($p < 0.006$) in plasma of the aging, arteriosclerotic subject and has an abnormal distribution pattern between α and β lipoproteins of the pathological patient. This deficiency of lipid bound glutamic acid may be related to a defective blood coagulation system of the human arteriosclerotic.

Microbiology

Physiology of toxin production by Clostridium botulinum types A and B. I. Growth, autolysis, and toxin production.

BONVENTRE, P. F. AND KEMPE, L. L. (Univ. of Michigan, Ann Arbor). *J. Bacteriol. 79*, 18–23 (1960).

The normal growth cycle of the strains of *Clostridium botulinum* studied was found to be characterized by a period of cell multiplication immediately followed by active autolysis of the cells which continued until few viable organisms remained. Autolysis was established as an important mechanism for the liberation of the toxin.

Nutrition

Efficacy of the FAO amino acid reference standard for growth of the weanling rat.

HOWE, E. E., GILFILLAN, E. W. AND ALLISON, J. B. (Merck Inst., Rahway, N. J.) *J. Nutrition 70*, 385–90 (1960).

In rat growth experiments, the FAO (Food and Agriculture Organization of the United Nations) amino acid reference pattern was found to possess a somewhat greater efficiency than an amino acid mixt. patterned after casein at a high essential amino acid content. At a lower essential amino acid content the protein efficiencies were equal but the FAO pattern supported much more rapid growth when the diets were fed ad libitum. Decreasing the tryptophan content of the FAO pattern by 33 to 50% or increasing the lysine content by 22% did not alter the nutritive value of the mixture. A mixt. contg. casein supplemented to the FAO reference pattern with essential amino acids was found to be nutritionally equiv. to the FAO reference amino acid mixt. itself. Cottonseed meal so supplemented proved to be inferior to both.

Use of germ-free animals in research. (In German).

HAENAL, H. *Ernahrungsforschung 5*, 1–17 (1960).

A summary of the literature on germ free animals. Germ free animals breed and grow in the same manner as regular animals, with only minor differences. Organs develop normally, except those concerned with combating bacteria, e.g. lymph nodes, which are smaller. Some

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25 YEARS

vitamins such as nicotinic acid, folic acid, biotin have been proved to be synthesized by the intestinal flora of normal animals. 46 references.

Dental caries and growth in rats fed whole-milk powders with increasing lysine deterioration.

CREMER, H. D., KINKEL, H. J. AND MAURON, J. (Research Labs., Nestle's Products, Vevey, Switzerland). *J. Nutrition 70*, 533–6 (1960).

A series of whole-milk powders with increasing lysine deterioration was prepd. by intensifying the heat treatment during roller drying. Lysine availability in the powders was measured by in vitro digestion. Diets contg. 40% of these milk powders were fed to young rats, and caries incidence and growth detd. No relationship whatsoever could be found between caries incidence and lysine deterioration, whereas growth was progressively reduced as lysine deterioration increased.

Acute iron poisoning in children.

SISSON, T. R. C. (Ortho Research Foundation, Raritan, N. J.). *Quart. Rev. Pediatrics 15*, 47–9 (1960).

Hematinics are widely prescribed and should be kept away from small children. Iron is rapidly absorbed in the gastrointestinal tract and causes profound metabolic changes, acidosis, hypotensive shock, and damage to the liver and intestinal mucosa. Death is due primarily to cardiovascular collapse. Treatment of acute iron poisoning should concentrate on binding and removing the excess iron in the intestine, tissues, and blood and on overcoming shock.

Effects of nicotinic acid and related compounds on sterol metabolism in the chick and rat.

GAYLOR, J. L., HARDY, R. W. F. AND BAUMANN, C. A. (Univ. of Wisconsin, Madison). *J. Nutrition 70*, 293–301 (1960).

High levels of nicotinic acid, comparable to those used in human therapy, were fed to rats and chicks, and the effects compared with those resulting from nicotinamide, isonicotinic acid or benzoic acid. Of the substances tested, isonicotinic acid appeared to produce the least alteration in growth, liver pyridine nucleotide levels, or liver cholesterol concns., while yielding the most consistent lowering of blood cholesterol in both the rat and the chick.

Toxicology

Beneficial effects of alfalfa meal and other bulk-containing or bulk-forming materials on the toxicity of non-ionic surface-active agents in the rat.

ERSHOFF, B. H. (Univ. of Southern Calif., Los Angeles). *J. Nutrition 70*, 484–90 (1960).

Further data are presented on the comparative effects of alfalfa and other bulk-forming or bulk-contg. materials on symptoms of toxicity assocd. with feeding of high levels of surface-active agents in the rat. Supplements of alfalfa meal were without protective effect in diets contg. Span 20 but counteracted the deleterious effects of Myrj 52, Tween 20 and Tween 60 administration. The protective factor(s) in alfalfa was retained in the alfalfa residue fraction (water-washed pulp remaining after extn. of the juice). Supplements of protein, fat and the known vitamins were without effect. Purified cellulose however, had significant effect on the toxic effects of Myrj 52, Tween 20 and Tween 60 administration. Sodium alginate and carrageenin counteracted symptoms of Tween 60 toxicity.

The toxicity of injected peptides as related to peptidase activity in peritoneal fluid.

JOHNSTON, J. M. AND WIGGANS, D. S. (Univ. of Texas, Dallas). *Arch. Biochem. Biophys. 87*, 167–70 (1960).

Peptidase activity is normally present in cell-free peritoneal fluid. A specificity of hydrolysis for a number of peptides has been demonstrated. A comparison of peptidase activity in the peritoneal fluid obtained from rats and from humans shows no marked differences in substrate specificity for peptides examd. The lethal effects of injected amino acids may be decreased or abolished when combined in peptide form. A degree of correlation exists between the peptidase activity in the peritoneal cavity and the toxicity of the injected peptides.

Anti-inflammatory activity of some water-soluble bioflavonoids.

MENKIN, V. (Temple Univ., Philadelphia, Penna.). *Am. J. Physiol. 196*, 1205–10 (1959).

The water-soluble citrus bioflavonoid mixt. contained in the prepn. C.V.P., without added vitamin C, is capable of inhibiting the increased capillary permeability referable in turn to an inflammatory exudate, irrespective of the pH of that exudate. The suppressing effect of these water-sol. bioflavonoids can be demonstrated in concns. of 5 or 10 mg./0.25 ml. of exudative material. They likewise inhibit the effect of leukotaxine that has been extd. from alkaline exudates.

The irritating effect of surface-active substances on the eyes of rabbits. (In German).

MEINICKE, K. *Fette, Seifen, Anstrichmittel 62*, 107–12 (1960).

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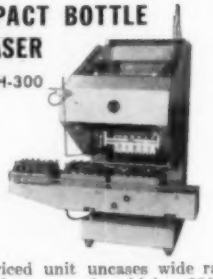

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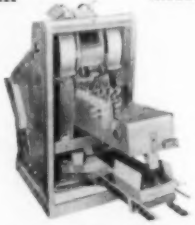

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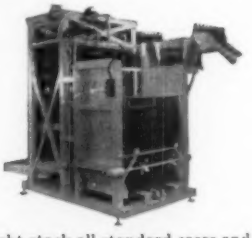

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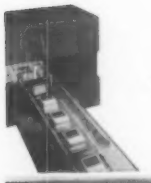

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SENSITIVITY TABLE

MODEL	APERTURE SIZE	MINIMUM SPHERICAL PARTICLE DIAMETER IN INCHES		
		Magnetic Metal (Steel)	Non-Magnetic Low-Resistance Metal (Brass, Copper, Aluminum)	Non-Magnetic High-Resistance Metal (Stainless Steel, Monel)
S-850	3½" x 8½"	0.062	0.106	0.156
S-850A	2" x 8½"	0.039	0.060	0.115
S-850B	6" x 8½"	0.090	0.140	0.192
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ENGINEERING RESEARCH

Hydraulic transport of solids through a vertical pipe.

GLIDDON, B. J. (Ph.D. Thesis, London University, Engl.). *Brit. Chem. Eng. 5*, 280 (1960).

The hydraulic transport of solids from .0040 in. to .15 in. diam. and specific gravity from 1.2 to 4.6 in 1 in. and 2 in. pipes by water flowing at velocity up to 13 ft./sec. and contg. up to 35% by vol. solids was studied. Slurries of materials small enough to obey Stokes law give pressure drop curves which diverge from that of water as the velocity increases, while slurries of materials large enough to have free settling velocities in the transition or turbulent region have pressure drop curves which are the same as clear water flowing at the same velocity. These coarser solids travel in a homogeneous core surrounded by a clear water annulus. The velocity profile is considerably flatter than that of water flowline at the same velocity. The difference between the average water velocity and the average particle velocity was equal to the free settling velocity of the particles.

FOOD AND FOOD TECHNOLOGY

Additives

The chemical preservation of food.

SPENCER, M. (Natl. Coll. of Food Technol., Weybridge, Surrey, Engl.). *Food Trade Rev. 30*, 49–52 (Apr. 1960).

Listed are chemical preservatives and antibiotics that may be incorporated into food products to make the food more palatable. Article is aimed at making food more accessible to populations throughout the world.

Preservation process with alkyl guanidines.

MICHENER, H. D. AND LEWIS, J. C. Assignors to the United States of America. U. S. 2,934,438. Apr. 26, 1960.

In order to prevent microbial spoilage, an alkyl guanidine (50 to 1000 p.p.m.) is incorporated into a foodstuff and the resulting mixt. subjected to heat at a temp. and for a time sufficient to produce a sterile substance. The time and temp. are substantially less than would be required to attain sterility in the absence of the alkyl guanidine.

Preservation process with diepoxybutane.

MICHENER, H. D. AND LEWIS, J. C. Assignors to the United States of America. U. S. 2,934,439. Apr. 26, 1960.

Diepoxybutane (50 to 1000 p.p.m.) when added to a foodstuff and subsequently heated to sterilization temp. protects the food from microbial spoilage and permits lower temp. and time than that required to attain sterility in the absence of the compds.

Antioxidants

On the antioxidant activities of the tocopherols. II. Influence of substrate, temperature and level of oxidation.

LEA, C. H. (Low Temp. Research Sta., Cambridge, Engl.). *J. Sci. Food Agr. 11*, 212–18 (1960).

The antioxidant activities of the tocopherols have been compared at 60° and at 37° in distd. methyl esters of cottonseed, linseed and cod liver oil fatty acids contg. small addns. of oxidized ester as 'starter'. In the linoleate (cottonseed) system the γ- and δ-compds. were the most and the α-, ζ- and ε-compds. the least effective in extending the induction period. In the poly-unsatd. (linseed and cod liver oil) systems the γ- was still good, but the δ- was at the bottom of the series and the α- and ζ-compds. near the top. Under suitable conditions α-tocopherol could be shown to exert the highest and δ- the lowest in vitro antioxidant activity, in agreement with their known in vivo vitamin E potencies.

Baking and Bakery Products

Manufacture of bakers' yeast by continuous fermentation.

OLSEN, A. J. *Chem. & Ind.* 416–25 (1960).

The author describes engineering and process features of the first plant for commercial production of bakers' yeast without alcohol, by continuous fermentation. The maximum capacity of the plant was increased from 225 tons/week on the batch process to 300 tons/week for the continuous process, by the use of several vessels in series.

Cocoa and Cocoa Products

Enzymatic changes in cacao beans during fermentation. (In German).

PURR, A., SPRINGER, R. AND MORCINEK, H. *Z. Lebensm.-Untersuch. u-Forsch. 112*, 40–6 (1960).

Chemical changes of the primary oxidation products of the enzymatic pyrocatechol oxidation with proteins, peptides and the amino acids occurring in cacao protein are described. The polyphenol-oxidase-activity in ungerminated beans and the amt. of the increase in activity is dependent upon the type of bean. Of the peptides studied, glycyl-glycine exerts the strongest influence on oxygen absorption; in the case of DL-leucyl-glycine, no reaction is observed. Of the amino acids studied, glycine causes the highest absorption of oxygen; following in decreasing order are: DL-threonine, DL-serine, L-alanine and L-lysine.

Notes on chocolate tempering and coating.

NEWTH, T. *Mfg. Confectioner 40*, 25–6 (Apr. 1960).

The drip feed method of handling chocolate coatings in the enrober is described. Untempered chocolate is fed into the enrober contg. a bed of tempered chocolate at the same rate as the tempered chocolate is used up. The seed bed in the enrober will temper the coating being fed into it and the untempered chocolate coating acts as a barrier to advancing crystallization. More uniform coatings, over extended time periods, result from this method.

Dehydration

Drying.

MCCORMICK, P. Y. (E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.). *Ind. Eng. Chem. 52*, 439–40 (1960).

Among the outstanding developments in drying equipment in recent years is the adaptation of spray driers to the agglomeration of dehydrated food products, especially in the improvement of solids dispersion of milk powders and cocoa mixes. Progress in the fields of tray drying using super heated steam, mechanisms of heat and mass transfer, ultrasonics in drying, and in spray driers are also reviewed giving original references.

A bright future for potato dehydration is warranted.

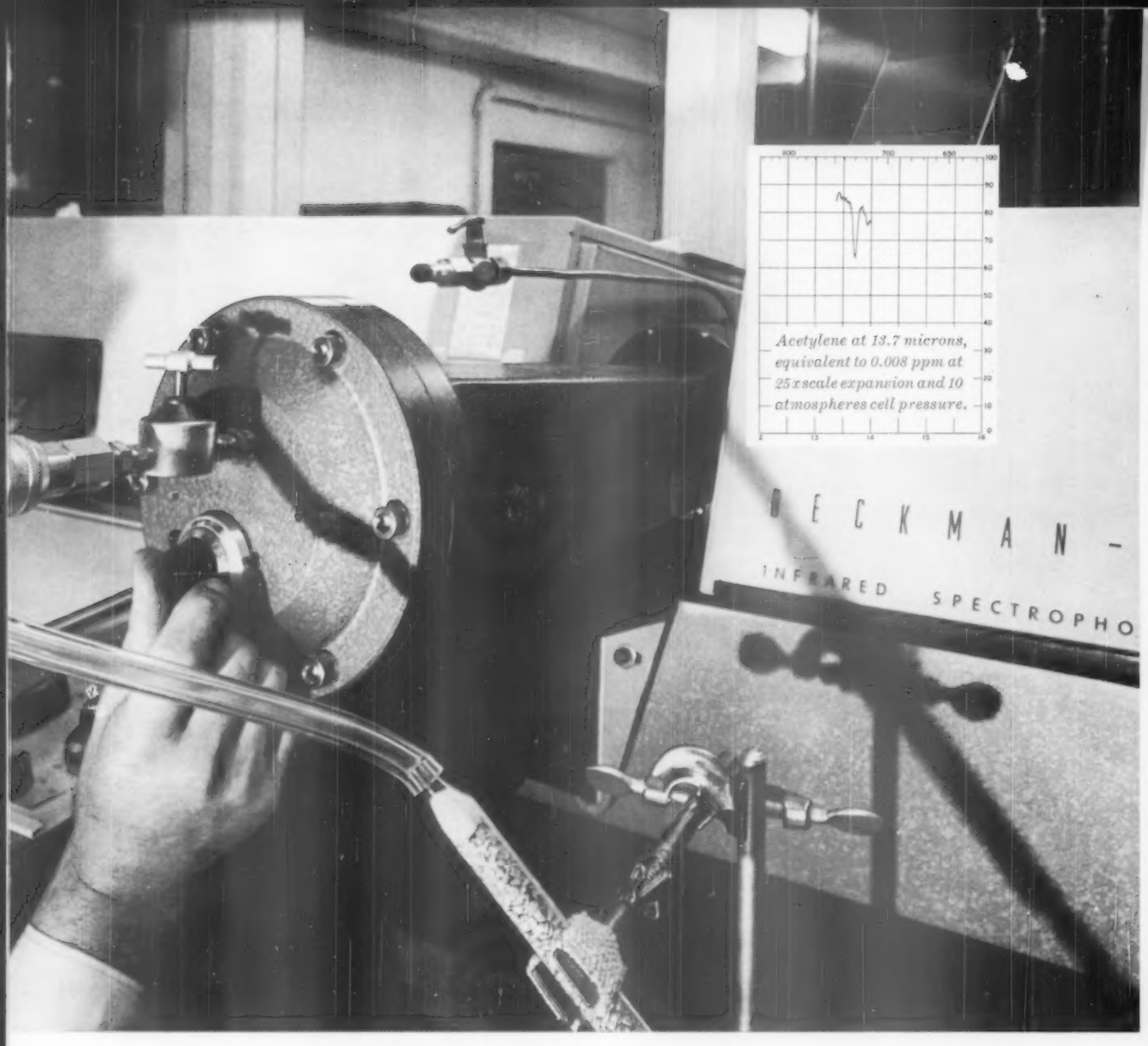
MEDRICZKY, A. *Am. Potato J. 37*, 77–80 (1960).

The author comments on the rapid growth of the potato dehydration industry based on his experiences in post-war Germany. Several new processing methods are suggested, among them the preservation of the whole potato substance by transformation into a coarse grits form, saving as much as possible of the water-soluble and heat susceptible ingredients.

Legislation

The new additives regulations for Western Germany. Part II. Coloring matter and general additives.

HINTON, C. L. *Food* (Brit.) *29*, 123–5 (1960).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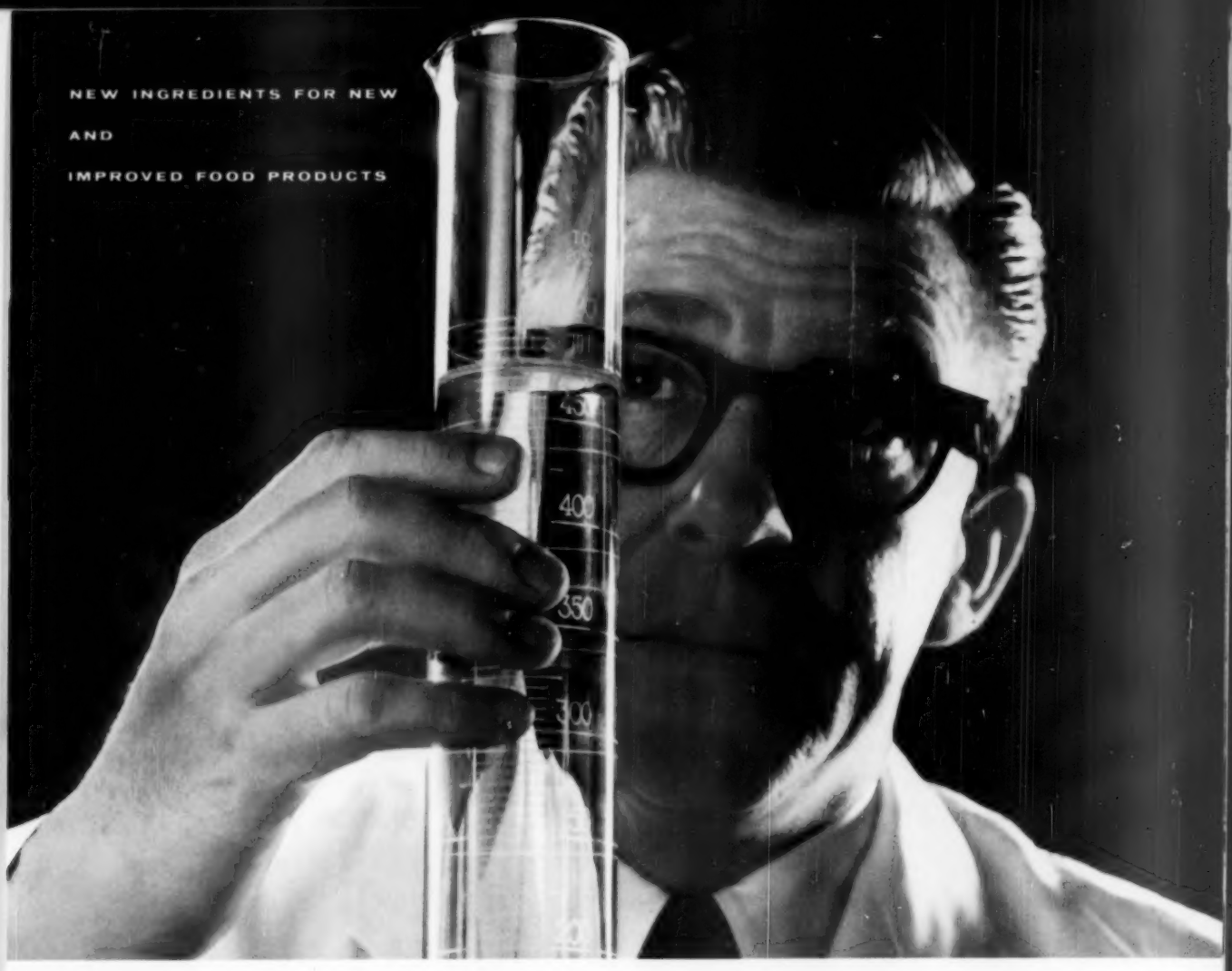

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The Coloring Matters Order in the new series of regulations specifies lists of coloring matters which are the only ones permitted to be used in or on foods, and then only for certain named foods in limited quantity. Declaration of the presence of the added coloring matter is required, with some exceptions, and provisions are included for the packaging and labelling of the coloring matters themselves.

Meat

A polarographic method for determining nitrite in meat-curing brines.

DHONT, J. H. (Central Inst. for Nutrition and Food Research T.N.O., Utrecht, The Netherlands). *Analyst 85*, 144–6 (1960).

A polarographic method for detg. nitrite is described; it is based on the formation of 1-nitroso-2-naphthol from nitrite and 2-naphthol. The nitroso compd. is reduced at the dropping-mercury electrode. The completeness of the reaction, the effect of interfering substances, the reproducibility and the recovery have been investigated.

Process for the preparation of a meat flavor.

MAY, C. G. AND MORTON, I. D. Assignors to Lever Brothers Co. U. S. 2,934,436. Apr. 26, 1960.

A process for the prepn. of a meat flavor, in which cysteine is heated with glyceraldehyde in the presence of water until a meat flavor develops.

Milk and Milk Products

Coconut-like flavor defect of milk fat. IV. Demonstration of δ-dodecalactone in the steam distillate from milk fat.

THARP, B. W. AND PATTON, S. (Pennsylvania Agr. Expt. Sta., University Park). *J. Dairy Sci. 43*, 475–9 (1960).

Liquid-partition chromatography, using various solvent systems on paper and in packed columns together with gas-liquid chromatography, enabled the identification of δ-dodecalactone in the steam distillate from fresh milk fat. It appears that this lactone occurs in the distillate at a lower level than does δ-decalactone. Because of its characteristic fruity flavor and odor properties, δ-dodecalactone is considered to be of possible significance in flavor changes of processed and stored dairy products. A useful column partition system for chromatographic sepn. of certain aliphatic lactones was revealed in the course of the investigation.

Retail sales of nonfat dry milk. I. Characteristics of consumer purchases and use. II. Relationships between nonfat dry milk and fluid milk purchases.

OLDENSTADT, D. AND CHRISTENSEN, S. K. *Tech. Bull. Oregon Expt. Sta. 48*, 32 (1959).

Dried milk products including dried skim-milk, chocolate-flavored dried skim-milk, buttermilk and dried cream, were purchased by 41% of the households interviewed. About 24% used dried skim-milk regularly and in one week used an average of 5.4 quart equivalents (this was estd. as about 67 quart equivalents annual consumption) of dried skim-milk of which approximately 50% was reconstituted for drinking, 6% used for chocolate drinks and pet food and the remainder for cooking and baking. Consumers buying dried skim-milk regularly increased their total consumption of liquid and skim-milk by an average of 1.8 qt./wk.; the skim-milk purchases were used to replace an average of 3.6 qt. of liquid whole milk/wk. This amt., considered in relation to all households, equals about 10% of the estd. per capita liquid milk consumption.

Starch

Investigations of the retrogradation of amylose. (In German).

HOLLO, J., SZEJTLI, J. AND GANTNER, G. S. *Die Starke 12*, 73-7 (1960).

The retrogradation of starch was studied by measuring the iodine binding capacity amperometrically. The velocity of retrogradation decreased with increasing temp. Amylose retrograded the quickest around the neutral point. Potato amylose contg. 1–2 ramifications/mol., aged less rapidly than wheat amylose contg. no ramification. Under the influence of salts amylose first lost its hydrate water hull, and then pptd. and retrograded.

Taste Testing

World food supplies. 3. Choice of foods.

AYLWARD, F. *Food Manuf. 35*, 148–53 (1960).

The third of this series of articles outlines the basic facts of nutrition, discusses the different food habits of various peoples of the world, and shows how nutritional assessments must take into account indigenous non-staple foods which, however repugnant they may be to sophisticated Westerners, are the result of accumulated age-long wisdom. Drastic changes in these indigenous food habits might lead to widespread malnutrition.

Miscellaneous

Ultrasonics—new process tool for U. S. food packers.

SHERWOOD, P. W. *Canner/Packer 128*, 20–1 (Sept. 1959).

The applications of ultrasonics in the areas of instrumentation and processing, of the food industry are itemized. Potential uses are listed in dispersive, flocculative, chemical and biological categories. Ultrasonics is currently being employed in the homogenization of peanut butter, ice cream mix, puddings, soups, and salad dressings, and in the sterilization of milk and degassing of bottled beer.

PHYSICAL METHODS

A theory and method for the spreading of protein monolayers.

TRURNIT, H. J. (Research Inst. for Advanced Study, Baltimore, Md.). *J. Colloid Sci. 15*, 1–13 (1960).

Protein monolayers, or true H-films, can be spread quickly and without loss on distd. water or dil. buffer solns., if the protein soln. before reaching the water surface of the film trough is spread out into a very thin layer around a glass rod. During the flow time along the glass rod the vast majority of all protein molecules diffuse to the water/air interface and spread, if flow rate, protein concn., glass rod length, and diameter are chosen correctly. The influence of these parameters is investigated theoretically, and the theoretical predictions are compared with results from spreading expts.

INDUSTRY NEWS

PROCESSES

American Maize-Products Company, processor of corn into a wide variety of food-grade and chemical products, has embarked upon a discovery and development program in the field of starch phosphates that offers promise of a whole new family of end uses of corn. One new group of products called starch phosphates already is in production in research quantities in a pilot plant, and American Maize's manufacturing division has under study a large scale unit that may be producing commercial quantities by year end.

Basis of American Maize's long range program into the new field is a number of process, use and product patents licensed on an exclusive basis from International Minerals and Chemical Corporation. Dr. James W. Evans, vice president in charge of research and development for American Maize, said that the new starch phosphates

new SENTRY Sorbic is snow-white and free-flowing

Developed by CARBIDE research just a few years ago, SENTRY Sorbic has become one of the most dependable and widely used mold inhibitors for control of food spoilage. And because research in product improvement never stops at CARBIDE, you can now get a *better* Sorbic—a reliable mold and yeast inhibitor that's pure-white and completely free flowing, with little detectable odor to affect the flavor or aroma of your most delectable foods.

Sorbic is widely used in many types of cheese, sliced or cut for sale in consumer-sized packages. Pies, cakes, and other baked goods can now maintain longer shelf-life—and extended saleability—with Sorbic. It is also effective in wines, prepared fruits, juices, and vegetables. Low concentrations, usually less than $^{1}/_{10}$ of one per cent, protect food products and your profits. And, since Sorbic is generally recognized as safe for such uses, there is no Food Additives Amendment problem!

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are what is known chemically as esters, this one being formed between the corn starch, which is an alcohol, and an acid, which is a blend of acid phosphate salts.

The span of possible industrial uses of the new starch phosphate is intriguing. The food industry, for example, will form an exceptional market where the starch phosphate, used as a thickener in sauces and gravies, will provide what is regarded as remarkable freeze-thaw stability. A major problem in several areas of the food industry is the curdled and spongy appearance that develops in some frozen and canned foods, such as frozen meat pies, Chinese foods and others. Use of the new starch phosphate, the initial research has demonstrated, guarantees the retention of smoothness in gravies with no effect upon eating properties.

IN MEMORIAM

Arthur H. Downey, vice president in charge of research and technology of Magnus, Mabee & Reynard, Inc., died on Monday, June 13, at Methodist Hospital, Brooklyn, New York, after a brief illness. He was 62 years old and a resident of Glen Rock, New Jersey. A graduate of Pratt Institute, Brooklyn, N. Y., Mr. Downey joined MM&R in 1921 as an analytical chemist, and was successively chief analytical chemist, production superintendent and, finally, director of all MM&R scientific activities. Mr. Downey was an active member of the IFT since 1942. He was also a member of the Essential Oil Association of the U.S.A., and the National Pickle Packers Association. Mr. Downey is survived by his widow, Mrs. Charlotte Downey; a son, Arthur H. Downey, Jr., and two daughters, Mrs. Mildred Sprunk and Mrs. Dorothy Voorhis.

A. H. Downey

PERSONNEL

Dr. Charles N. Frey, lecturer at Massachusetts Institute of Technology and Columbia University, and former Director of Scientific Relations, Standard Brands, Inc., received a Distinguished Alumni Award at the 100th Annual Commencement of Michigan State University at East Lansing, Michigan, on June 12.

An exchange team of food executives left June 24, 1960 for a tour of food plants and research institutions in Russia. The group and the tour were organized by the U. S. Department of Agriculture. **Dr. G. E. Hilbert,** Director of the Foreign Research & Technical Programs Division of USDA's Agricultural Research Service, is chairman of the team. The project comes under the agreement of three years ago between the U.S. State Department and the Soviet Foreign Office to exchange visiting teams of food processors and researchers.

Besides Dr. Hilbert, the American Food Industry Research Team consists of: Milan D. Smith, President, National Canners Association, Mr. W. R. McLellan, Vice President, Food Machinery Corporation International, San Jose, Calif.; **Dr. Eugen Wierbicki,** Rath Packing Company, Waterloo, Iowa; Mr. David M. Levitt, President, Doughnut Corporation of America, New York, N. Y.; Dr. **Fred E. Deatherage,** Chairman, Department of Biochemistry, College of Agriculture, Ohio State University, Columbus, Ohio; and Dr. O. W. Herrmann, Deputy Administrator, Agricultural Marketing Service, USDA, Washington, D. C.

Visits will be made to Russian canning, baking, dairy, freezing, grain, meat packing and sugar plants, as well as to various research institutions of these industries. The tour will divide about evenly between plants and institutions. Russian cities included are Moscow, Kiev, Kishenev, Kherson, Krasnodar, Tbilisi, and Baku.

First event on the itinerary will be a meeting with the State Scientific and Technical Committee of the U.S.S.R. Council of Ministers, in Moscow.

The first presentation of the recently established $250 Carrier Award, sponsored by the Carrier Corp. of Syracuse, N. Y., was made today to **Dr. Aaron L. Brody,** a food technologist in the research laboratories of the Whirlpool Corp., St. Joseph, Mich. Presentation of the award, granted to Brody as senior author of a paper, "Use of Activated Charcoal to Decrease Odor and Odor Transfer in Domestic Refrigerators," was made at the 67th annual meeting of the American Society of Heating, Refrigerating and Air Conditioning Engineers in Vancouver, B. C. The new award of the society is granted for the best paper presented at a national meeting of the society by an associate member under 30 years of age.

Robert A. Clabault of Bingham, Mass., has been appointed sales manager of the Container and Industrial Products Department, Dewey and Almy Chemical Division, W. R. Grace & Co., Cambridge, Mass. He will be responsible for sales of Dewey and Almy's "Flowed-in" sealing compounds for tin cans, glass jar closures, bottle crowns, aerosol cans, drums, pails, and industrial gaskets, and other products. Clabault, with Dewey and Almy since 1955, has served as sales engineer, product manager for commercial cap compounds, assistant manager of container products, and sales development manager.

R. A. Clabault

In another Dewey and Almy promotion, Edward L. Mears has been named vice president of the Chemical Division.

Dr. Katheryn E. Langwill, director of research for Refined Syrups & Sugars, Inc., Yonkers, N.Y., a subsidiary of Corn Products Company, has been selected by the American Association of Candy Technologists as the tenth recipient of the Stroud Jordan Award for her outstanding contributions to the field of candy technology. Dr. Langwill, who worked with the late Dr. Stroud Jordan from 1932 to 1942, is the first woman to receive the award.

Dr. Donald A. M. Mackay, recognized as one of the leading authorities in the applications of modern analytical instrumentation to many unexplored areas of chemical research, has been appointed Director of Research at Evans Research and Development Corporation, New York City. He has specialized in the use of highly advanced ionization detector gas chromatography, ultraviolet and infrared spectrophotometry, and radioisotope tech-

D. A. M. Mackay

Do you know these facts about PAPAIN?

Papain is the dried and purified latex of the Carica Papaya. The papaya tree grows and is extensively cultivated in every tropical country, including Ceylon, South Africa, Hawaii, the East and West Indies and Puerto Rico.

Q. *What is papain's action?*

A. Papain is a very powerful and versatile proteolytic enzyme, with properties unrivalled by any other proteinase.

Q. *Who uses it?*

A. A long list of industries, ranging from breweries to the pharmaceutical industry. About 80% of all beer brewed in the U.S. is stabilized and chill-proofed with papain. Papain tenderizes inexpensive beef cuts, and is used for this purpose both by packers and restaurants. It clarifies vegetable juices and pre-digests cereals. It is even used in chewing gum to help digest food particles lodged between the teeth. Medicinally, papain is used in the treatment of a variety of gastric disturbances, infected and healing wounds, fistulas, psoriasis and sores, as well as for vaginal douches, sloughing ulcers and necrotic tissues, burn therapy, and as a cleanser with suppurating lesions. The cosmetic industry uses papain in a variety of skin creams and lotions and in toothpastes and tooth powders. Tanners use papain to digest coagulated albumens, making hides readily wettable and workable. The textile industry uses it to de-size various fabrics, including synthetics and woolens.

Q. *What are papain's chemistry and physical properties?*

A. Imported crude papain contains much foreign matter, both organic and inorganic. These impurities are removed by a special purification process developed by the Meer Research Laboratories, resulting in an extremely stable papain. Besides the powerful proteinases papain and chymopapain, Purified Papain contains small amounts of supplementary enzymes that actually increase the digestive activity of these principal enzymes. In appearance, it is a yellowish-white powder with characteristic odor and taste, easily soluble in water, glycerine and low hydroalcoholic solutions. It is the most thermostable enzyme known. As a powder, it remains stable for hours at 105°C; in solution, it is active at the usual cooking temperatures. Even at 90°C it retains a considerable action. However, in storage, commercial papain may lose up to 50% of its activity. This is not true of Meer Purified Papain, which doesn't lose measurable amounts of activity during the same storage period.

Q. *In what forms is papain available?*

A. Purified Papain "Meer 70", adjusted with lactose to proteolytic activity of NF VIII standard, is available powdered to Mesh 60, in 50 and 100 pound polyethylene lined fibre drums. The other Meer grades, also available powdered to Mesh 60, are similarly packaged. These include Purified Papain Standard "Meer S-100", Purified Papain "Meer T-130" and Purified Papain "Meer A-160".

Q. *What other botanicals does Meer process?*

A. Practically every botanical known and used by man. Additional members of the Meer product line include gums, drug and flavor extracts and related products. Whatever, your needs you'll appreciate our painstaking quality control and our personalized service.

Detailed information on Meer Papain, including assay procedure, is available on request.

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nology, and is a well-known author and speaker on these subjects. Dr. Mackay, who joined Evans Research in 1953, has since conducted studies of keratin fibers, the preparation of sulfur-containing compounds, and flavor and odor problems in the food, cosmetic, and tobacco industries. He received his B.A. from Lincoln College, Oxford University, and in 1954 his Ph.D. from Yale University.

Francis A. Baldauski has been appointed assistant sales manager of Sterwin Chemicals Inc. He has been a technical sales representative for Sterwin in the metropolitan New York City area since joining the company in March, 1959. As assistant sales manager, Mr. Baldauski will supervise the sales of Zimco brand Lignin vanillin, Parakeet brand certified food colors and a number of additional Sterwin products distributed to the general food industry. He received his B.S. and M.S. degrees from Pennsylvania State University.

F. A. Baldauski

The appointment of **John Votel Rush** to the staff of Firmenich Incorporated was announced recently. Mr. Rush will be located in the company's Chicago office. Before joining Firmenich, he was a technical sales representative in the food and pharmaceutical industry for Sterwin Chemicals, and prior thereto was Chicago representative on pharmaceuticals and food for Mallinckrodt Chemical Works. He is a graduate chemist of the University of Illinois.

J. V. Rush

Marvin F. Peiser recently was elected Assistant Vice President in charge of Production of Polak's Frutal Works, Inc., Middletown, New York. For the past 14 years Mr. Preiser has been associated with the Flavor and Production Departments of P.F.W.

M. F. Preiser

Kenneth R. Leggett has been appointed executive administrative assistant to the president of Philips-Roxane, Inc., which sells human health pharmaceuticals and drugs within the United States. With his responsibilities primarily in the area of technical products evaluation, Mr. Leggett is now located at the home offices of the company, St. Joseph, Missouri. Prior to joining Philips-Roxane, he was technical director of C. Bowman Co. He has also held positions with American Cyanamid Co. and Sterwin Chemicals, Inc. Mr. Leggett received his Bachelor of Science in Chemistry from the University of New Hampshire.

K. R. Legett

Norman H. Ishler has been appointed associate director of technical services at General Foods Research Center, Tarrytown, New York. A graudate of Pennsylvania State University with a Bachelor of Science and Master of Science degrees, Mr. Ishler has been with General Foods since 1946. Hhe has held a succession of increasingly important research posts with General Foods and until his present promotion, was staff planning coordinator.

Dr. John L. Hickson of Glen Ridge, New Jersey, has been elected Vice President and Scientific Director of Sugar Research Foundation, Inc. He succeeds **Dr. Henry B. Hass,** who has resigned as President of the Foundation but will continue to serve as a consultant. The Sugar Association, Inc., is the parent group that directs the policies of the Foundation and Sugar Information, Inc. Dr. Hickson was graduated from Ohio Wesleyan University in 1937, received a master's degree in 1952 and a Ph.D. in 1953, both at Purdue University.

Appointment of **Roy Shaw** as manager of dried food product development for The Pillsbury Company was announced recently. A graduate of the University of California, Shaw was formerly assistant to the director of research and development for J. R. Simplot Company. He is a specialist in potato research and has been instrumental in development of several potato products.

Promotion of **Karl Klomparens** to industrial sales manager at Diamond Crystal Salt Co. has been announced by Spencer S. Meilstrup, vice-president and general sales manager. Klomparens had been technical director since joining the company in 1955. Prior to that, he served two and one-half years as assistant editor of *Food Processing*, two years at Swift and Company's dairy plant in Holland, Mich., and three years as an instructor in food technology at New York University. In his new position, he will coordinate sales efforts in baking, canning, confectionery, dairy, feed mixing, meat packing, milling, tanning, textile, water conditioning and other industrial fields. Klomparens is a chemistry gradu-

Karl Klomparens

ate of Hope College, Holland, Michigan, and holds a Master's Degree in Food Technology from Michigan State University.

Appointment of veteran food technologist **Ralph C. Lakamp** as director of the Kroger Food Foundation has been announced by Joseph B. Hall, president of the Kroger Co. He succeeds the late **George F. Garnatz**, who had headed the food testing organization since 1945 and was a past president of the IFT. Lakamp, 42, graduated from Ohio State University, where he majored in dairy technology, and completed a post-graduate course in food technology at Massachusetts Institute of Technology. He joined Kroger in 1945 and a year and a half later was named head of the Food Foundation's cereal laboratory. For the past year he has been chief of the general laboratory.

R. C. Lakamp

Albert Spiel has been named a section head at the General Foods Research Center, Tarrytown, New York. He has been a project leader since 1954, the year he joined General Foods. Mr. Spiel formerly was with the National Dairy Products Corporation as an associate scientist. He holds a Bachelor of Chemical Engineering Degree from City College of New York, and received his Master's in Chemical Engineering from the Polytechnic Institute of Brooklyn.

EXPANSION NEWS

A new and modern facility for the manufacture of process equipment was dedicated in Guadalajara, Jalisco, Mexico recently. Known as Swecomex, S.A., the 170,000 square foot facility will be used in the manufacture of process equipment including shell and tube heat exchangers, surface condensers, steam jet ejectors, distillation columns, evaporators, and crystallizers, for use by such basic industries as petroleum, natural gas, chemicals and petro-chemicals, minerals and metals, power generation, sugar, cement, pulp, paper, and foods. According to Swecomex, S. A., its products will be manufactured in accordance with the codes of the American Society of Mechanical Engineers and the Tubular Exchange Manufacturers Association. Inquiries should be directed to Mr. E. Harden Bishop, Executive Research, Inc., 1111 Wilshire Boulevard, Los Angeles 17, California.

FOOD TECHNOLOGISTS

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WANTED: FLAVOR CHEMIST—Experience in formulating flavors and handling essential oils, fruit juices, etc. Location, Greenwich, Connecticut area. Give personal information, salary requirements, references, etc. REPLY BOX 795, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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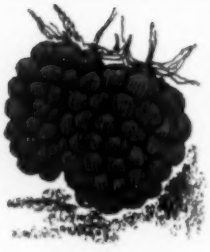

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